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THE ADDITION OF PROTEIN AND CALCIUM TO A RATION OF SMALL GRAINS FOR GROWING PIGS

R. D. SINCLAIR¹ AND L. W. MCELROY²

University of Alberta, Edmonton, Alberta

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It is well known that swine, of all farm animals, are the most likely to suffer from inadequate rations. This is due to two principal causes. In the first place they are fed largely on grain and get relatively little roughage, especially when they are fed under conditions of close housing and in the second place they grow more rapidly than other farm animals in relation to their weight at birth with the result that their requirements for essential dietary constituents are more exacting.

Chemical analyses only confirm what practical experience and experimental results have fully demonstrated—that the essential food constituents (aside from vitamins) most apt to be deficient in the ordinary farm grown grains, from the standpoint of the growing, fattening pig, are protein and the element calcium. According to Morrison's Feeding Standards (1) a pig of 75 pounds live weight would have to consume roughly $4\frac{1}{2}$ pounds of oats per day to obtain the required amount of digestible crude protein, while to secure .02 lbs. per day of lime (CaO) as recommended by Orr (2) it would have to consume 14 lbs. of the same grain. Since the other two grains commonly fed in Western Canada—barley and wheat—are quite similar in composition, it is obvious that young growing pigs cannot satisfy their demands for protein and calcium from grains alone.

Since protein and mineral supplements form the most expensive portion of a growing and fattening ration it therefore becomes important to make a careful study of the requirements of the pig for these constituents so that only the optimum amounts may be provided in the diet. Moreover, since the addition of protein to a basal ration of farm grains increases the rate of growth, thereby increasing the demand for material for skeletal development, it might be expected that the mineral requirements would vary somewhat with the level of protein intake. A series of experiments designed to study the effect of adding protein and calcium to a cereal ration for pigs was conducted at the University of Alberta during the summer of 1932, winter of 1932-33, summer of 1933, and winter of 1933-34.

PLAN OF THE EXPERIMENTS

These experiments were planned so that one group of pigs was carried on a non-supplemented cereal ration. Two series of groups were included, one with ground limestone added to the cereal ration as a source of calcium, and one without the addition of this mineral supplement. In both series the protein level of the ration was increased by stages by the addition of a supplement consisting of a meat meal and linseed oil meal mixture.

¹ Professor of Animal Husbandry.

² Graduate Student in Animal Husbandry, session 1933-34, now at Dominion Experimental Station, Lethbridge, Alta.

This arrangement of experimental groups made provision for a study of the effect of varying the level of protein in the ration under conditions of both low and high calcium intake and constituted a basis for determining the comparative deficiencies of protein and calcium in a ration made up of the small grains.

The pigs were confined to the piggery during the course of the experiments on a concrete floor provided with a wooden sleeping platform. The piggery was reasonably well lighted through ordinary glass windows. Straw was used for bedding.

In the first experiment the ration was hand fed in slop form and in the last three experiments dry feeding from self-feeders was practised.

From the point of view of arrangement of groups the following plan was adopted:

Group I. Basal ration.

Group II. Basal ration + 3.3% protein supplement.

Group III. Basal ration + 6.7% protein supplement.

Group IV. Basal ration + 10.0% protein supplement.

Group V. Basal ration + Gr. limestone.

Group VI. Basal ration + Gr. limestone + 3.3% protein supplement.

Group VII. Basal ration + Gr. limestone + 6.7% protein supplement.

Group VIII. Basal ration + Gr. limestone + 10.0% protein supplement.

Grain

The grain ration used in these experiments consisted of ground oats 50%, ground barley 25% and ground wheat 25%.

Protein Supplement

The protein supplement consisted of a packing house meat meal known as "Super 70" meat scrap together with linseed oil meal. The meat meal made up 75% of the mixture with linseed oil meal 25%. This particular mixture was used with a view to securing a mixture carrying a relatively low ash content.

Ground Limestone

In the groups receiving additional calcium this was added as finely pulverized ground limestone in the amount of 2 pounds per 100 pounds of grain and supplement mixture. A slight deviation from this plan was made in the fourth experiment when the amount of ground limestone was reduced to 1 lb. in 100 lbs. during the latter stages of the trial.

Salt

In all groups 1 pound of salt was added to 100 pounds of the grain and supplemental mixture.

Cod Liver Oil

In the first experiment each pig was fed 10 ccs. of crude cod liver oil daily. In the last three experiments of the series the cod liver oil was fed at the rate of 1 pound to each 100 pounds of the ration.

Chemical Analysis of the Ration

In connection with all experiments composite samples of the various feed sused were collected during the progress of the trials and the percentage of crude protein, calcium and phosphorus was determined. The results

of these analyses based on an average of the four experiments is shown in Table 1.

TABLE 1.—CHEMICAL ANALYSIS OF THE RATION

| | Oats | Barley | Wheat | Meat meal | Linseed oil meal |
|---|-------|--------|-------|-----------|------------------|
| Crude protein, % | 12.59 | 12.70 | 13.19 | 70.47 | 39.44 |
| Ash, % | 2.87 | 2.18 | 1.63 | 7.07 | 4.78 |
| CaO of ash, % | 1.81 | 1.45 | 2.05 | 26.10 | 8.77 |
| P ₂ O ₅ of ash, % | 25.03 | 33.28 | 48.84 | 34.02 | 30.74 |

The figures secured from these analyses were used as a basis for calculating the daily intake of the various food factors under consideration. The low ash content of the cereals is worth noting and in addition the high proportion of phosphorus to calcium is of special significance.

RESULTS OF THE EXPERIMENTS

Space will not permit the presentation of data nor a discussion of the results of individual experiments. Since the same general plan was followed in all experiments it has been thought proper to present tables and a discussion based on average results of the four trials. The only major deviation from the plan already outlined occurred in Experiment IV when Lot VIII (basal ration + ground limestone + 10% supplement) was eliminated and a group, designated as Group A, where the non-supplemented cereal ration fed without the addition of cod liver oil was included.

The results of the experiments will be interpreted on the basis of growth rates, feed utilization and blood composition, in terms of calcium and inorganic phosphorus of the serum. Blood samples were taken from the tail and analysed for calcium according to the Clark-Collip Modification of the Kramer-Tisdall method and for inorganic phosphorus by the Fiske and Subbarrow method.

Daily Intake of Food

In order to obtain a picture of the daily intake of protein, calcium and phosphorus and to study the effect of modifying the percentage of protein supplement in the ration as well as adding ground limestone on the intake of these constituents, Table 2 is presented. The figure for Digestible Crude Protein was obtained by applying the digestibility co-efficients of Henry and Morrison to the figures obtained by chemical analyses of the individual feeds. Weights are expressed in grams rather than in pounds in order to enable the figures for calcium and phosphorus to be more easily related to similar studies.

It will be noted that the average daily intake per 100 pounds live weight of digestible crude protein varied from 174 grams in Lot I to 256 grams in Lot VIII. According to Morrison's Feeding Standards (1) pigs of 100 pounds live weight should receive in the region of 235 grams (0.52 lb.) of digestible crude protein daily. Using Wood's Feeding Standards as a basis Davidson (3) places the digestible crude protein requirement of 100-pound pigs at a similar level of 0.51 lb. per day. These figures, then, would indicate that the grains used were definitely deficient in protein since it required the addition of 10% of the supplement used to raise the level of protein to meet these recommendations.

The calcium intake in the different lots varied rather widely, from 0.52 grams daily in Lot I to 14.84 in Lot VIII or from 0.030% to .865% of the ration. Taking as a basis the recent work of either Spildo (4) who considers that about 5-7 grams (0.35% of the ration) of calcium should be supplied per animal per day for growth alone, or of Bethke, Edington and Kick (5) who found that calcium should constitute about 0.6-1.2% of the ration, it is quite evident that a basal ration of farm grains as fed to Lot I is very deficient in the element calcium. Even when the basal ration was supplemented with 10% (Lot IV) of the protein supplement, the level of calcium being fed remained well below either of these recommendations. The addition of 2 pounds of ground limestone to each 100 pounds of the grain mixture provided approximately twice as much calcium as is recommended by Spildo and brought the figure into the region recommended by Bethke, Edington and Kick.

TABLE 2.—DAILY INTAKE OF D.C.P., CALCIUM AND PHOSPHORUS PER 100 LBS. LIVE WEIGHT

| Lot No. | Daily food intake gms. | Total D.C.P. gms. | Per cent of ration D.C.P. | Total Ca gms. | Per cent of ration Ca | Total P gms. | Per cent of ration P | Ratio Ca : P |
|---------|------------------------|-------------------|---------------------------|---------------|-----------------------|--------------|----------------------|--------------|
| I | 1720 | 174 | 10.2 | 0.52 | .030 | 5.56 | .323 | .092 : 1 |
| II | 1706 | 200 | 11.8 | 1.11 | .065 | 5.87 | .344 | .190 : 1 |
| III | 1692 | 226 | 13.4 | 1.70 | .101 | 6.19 | .365 | .278 : 1 |
| IV | 1695 | 254 | 15.0 | 2.29 | .135 | 6.56 | .385 | .352 : 1 |
| V | 1818 | 180 | 10.0 | 13.07 | .722 | 5.76 | .317 | 2.30 : 1 |
| VI | 1802 | 207 | 11.6 | 13.46 | .746 | 6.07 | .338 | 2.22 : 1 |
| VII | 1738 | 227 | 13.2 | 13.53 | .778 | 6.22 | .358 | 2.18 : 1 |
| VIII | 1714 | 256 | 15.0 | 14.84 | .865 | 6.38 | .372 | 2.33 : 1 |

The phosphorus requirement also is placed by Spildo (4) at about 0.35% of the ration, while the Ohio workers (5) place the figure at 0.6% of the ration. If the Ohio figures are to be taken as applicable to the conditions of this experiment, it might appear that the phosphorus as well as the calcium content of the ration was low. On the basis of Spildo's figures, however, the phosphorus content of the ration was just sufficient.

It must be noted here that according to the recommendations of the above workers, the Ca : P ratio was somewhat too wide in all lots which received ground limestone.

Rate of Growth

The pigs confined to the basal ration in these experiments made very unsatisfactory gains as compared with those whose rations were supplemented by the protein mixture or by ground limestone or a combination of both. The rate of growth of these pigs indicates quite definitely that a ration composed of cereals alone is unsatisfactory for pigs of the ages and weights used in these trials. The addition of the protein mixture in percentages of 3.3 to 6.7% and 10% resulted in progressive improvement in rate of growth, the increase in the rate of gains over the basal group being on the order of 35%, 57% and 75% as the protein allowance was increased.

That a calcium deficiency also was in part responsible for the indiffer-ent growth rate of the pigs receiving the basal ration only, is indicated

TABLE 3.—AVERAGE DAILY GAINS

| Lot No. | | Average initial weight lbs. | Average final weight lbs. | Average daily gain lbs. |
|---------|-----------------------------|-----------------------------|---------------------------|-------------------------|
| I | Basal | 50.7 | 139.1 | 0.69 |
| II | Basal + 3.3% P.S. | 51.0 | 170.8 | 0.93 |
| III | Basal + 6.7% P.S. | 50.9 | 184.8 | 1.08 |
| IV | Basal + 10.0% P.S. | 50.3 | 199.6 | 1.21 |
| V | Basal + Gr. L. | 50.3 | 166.9 | 0.92 |
| VI | Basal + Gr. L. + 3.3% P.S. | 50.8 | 196.1 | 1.20 |
| VII | Basal + Gr. L. + 6.7% P.S. | 49.9 | 200.1 | 1.24 |
| VIII | Basal + Gr. L. + 10.0% P.S. | 50.1 | 200.6 | 1.27 |

by the improvement effected by adding ground limestone. When ground limestone was added without any change in the protein fraction of the ration the rate of gain was increased from .69 pound to .92 pound daily. The addition of ground limestone to the groups receiving the 3.3% and 6.7% protein allowances also resulted in a significant improvement in daily gains indicating that calcium deficiency was a growth limiting factor in Lots II and III. The point at which the addition of ground limestone appeared to fail to make a marked impression on the rate of gains was when the protein supplement mixture was added at the rate of 10%. This would suggest that the additional calcium supplied by the protein supplement when fed at the 10% level was almost sufficient to satisfy at least the minimum requirements of the pigs for this element. A reference to Table 2 shows that these pigs received a daily quota of 2.29 grams of calcium (0.135% of the ration) and 254 grams of digestible crude protein (15% of the ration) per 100 lbs. live weight. In contrast to this, the pigs receiving 10% of the protein supplement + ground limestone received 0.865% calcium and 15% digestible crude protein.

Since the pigs on a daily intake of 2.29 grams of calcium made as satisfactory growth as other pigs receiving much larger allowances it would appear that the optimum allowance for such pigs as were used in these trials cannot be greatly in excess of the above figures. It may at least be suggested that the amount of from 13 to 14 grams is considerably in excess of actual requirements. In this connection it may be pointed out that no cases of crippling occurred in the 10% protein-no limestone lot, an occurrence which indicates that the calcium intake was sufficient and the Ca/P ratio such that clinical symptoms of rickets or related conditions were prevented. However, since crippling occurred in the other groups in the "no limestone" series it is obvious that the daily intake of 2.29 grams was decidedly marginal.

From the standpoint of rate of gains it would seem that a daily allowance of digestible crude protein up to 250 grams, or at the rate of 15% of the ration is justified as compared with the use of more limited allowances. That the drawing of any definite conclusion in this regard is not justified, however, is indicated by the fact that when ground limestone was supplied and the complication of calcium deficiency was removed the use of the protein supplement at the lower levels gave almost as good results

as when fed at the rate of 10%. The introduction of additional calcium through the increasing ash content of the protein supplement when fed in increasing amounts introduces a conflicting situation which makes it inadvisable to be too dogmatic regarding the optimum protein allowance. Had an adequate protein supplement with an even lower ash content than the one used in this experiment been selected it might have been possible to make a more definite recommendation in this regard. It is obvious that the fluctuations in ash content of various protein supplements must be taken into account when their efficiency is being considered. The growth curves shown in Figure 1 will be of interest in connection with a comparison of the rate of growth in the various groups.

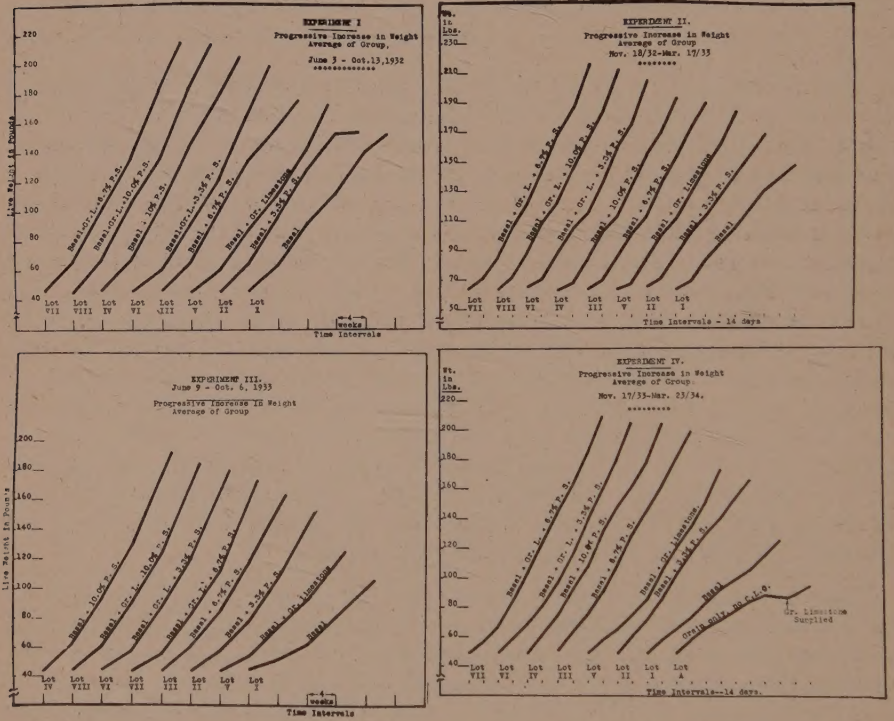


FIGURE 1. Growth curves for four experiments showing comparative growth rates for the various group of pigs.

Feed Requirement for Growth

Turning to a consideration of the various groups from the standpoint of efficiency of food utilization, it will be noted from Table 4, that the pigs receiving the grains non-supplemented made a poor showing as compared with the other groups on the experiment. The figure of 524.8 pounds of grain for 100 pounds increase in live weight suggests inefficient production in the basal group. The addition of the protein supplement in varying amounts, as was the case in respect to daily gains, resulted in progressive decreases in the amount of feed required per unit of increase in live weight. The saving in feed resulting from the addition of the protein mixture may best be expressed in terms of pounds of grain saved by each one pound of supplement fed. Reference to Table 4 will show that one pound of the

supplement replaced 6.3 pounds of grain when fed at the rate of 3.3%, 5.4 pounds when fed at the rate of 6.7% and 4.5 pounds when 10% was allowed. When fed without ground limestone the use of the supplement up to 10% would be justified when the cost of one pound would not exceed the value of 4.5 pounds of grain. Without regard to economy, it may be stated that under the conditions of the first four lots of the experiment, improvement was effected in feed utilization when the total digestible crude protein content of the ration was increased to 15% (Table 4).

When the mineral content of the ration was fortified by ground limestone a somewhat different situation developed. Under these conditions the improvement effected by the increase in the ash content when the protein supplement was fed at the higher levels was eliminated and a truer value for protein was secured. When Lot V is used as the check lot in the limestone series the grain saved by each pound of the protein mixture amounts to 5.5 lbs. in the 3.3% group, 4.5 lbs. in the 6.7% group and 3.7 lbs. in the 10% group, figures which are lower than when the limestone was not included. If economy of production is disregarded, it may be concluded that the use of the protein supplement up to a point where 15% of digestible crude protein was supplied was justified; but, since the saving of grain by the supplement diminished to a point where only 3.7 pounds of grain was replaced by each one pound of supplement when it was fed at the 10% level the practical value of feeding at that rate is open to question. Placing an arbitrary value of 0.5 cents per pound on the grains fed it would be necessary to secure the supplement at a cost of below \$30.00 per ton before its use at the higher level would be justified.

TABLE 4.—FEED REQUIREMENT FOR GROWTH

| Lot No. | Average daily feed consumed, lbs. | Pounds feed required per 100 lbs. gain | | | Pounds grain saved by 1 lb. of: | |
|---------------------------------|-----------------------------------|--|------|--------|---------------------------------|--------|
| | | Grain | P.S. | Gr. L. | P.S. | Gr. L. |
| I Basal | 3.64 | 524.8 | — | — | — | — |
| II Basal + 3.3% P.S. | 4.16 | 433.0 | 14.6 | — | 6.3 | — |
| III Basal + 6.7% P.S. | 4.41 | 378.2 | 27.3 | — | 5.4 | — |
| IV Basal + 10.0% P.S. | 4.69 | 350.1 | 38.9 | — | 4.5 | — |
| V Basal + Gr. L. | 4.35 | 463.3 | — | 8.6 | — | 7.2 |
| VI Basal + Gr.L. + 3.3% P.S. | 4.90 | 389.5 | 13.4 | 7.5 | 5.5 | 5.8 |
| VII Basal + Gr.L. + 6.7% P.S. | 4.79 | 351.5 | 25.1 | 7.0 | 4.5 | 3.8 |
| VIII Basal + Gr.L. + 10.0% P.S. | 4.75 | 329.4 | 36.5 | 7.3 | 3.7 | 2.8 |

Attention must be drawn to the saving of grain by the use of ground limestone. The addition of ground limestone resulted in a marked improvement in efficiency of feed utilization, indicating that calcium as well as protein deficiency in the farm grown grains is definitely a limiting factor in securing satisfactory returns on grain consumed. Reference to Table 4 will suggest that in the main, one pound of ground limestone had a higher replacement value than one pound of the protein supplement. This, combined with the fact that there was no indication of crippling in the "no protein supplement-limestone" group, (V) justifies the statement that calcium deficiency constitutes a more serious limiting factor than

protein deficiency in the development of such pigs as were used in the series of experiments under review.

It will be noted that as the percentage of protein supplement in the ration was increased the grain replacement value of the ground limestone was diminished. Its replacement value was highest when the protein supplement was not fed or was fed at the lower levels.

Calcium and Inorganic Phosphorus of the Blood Serum

In two of the experiments conducted (I and IV) the level of blood calcium in the basal, 3.3% and 6.7% protein supplement groups fell below 10 mg. per 100 cc. of blood serum. The low level of blood calcium was accompanied by the development of stiffness or actual crippling in these lots. The severity of the condition increased as the level of blood calcium fell. Similar results were obtained by Sinclair (6). In Experiments II and III, although the level of blood calcium in the "no limestone" groups was lower than in the "limestone" groups, it did not fall below 10 mg. The few cases of stiffness which developed in these trials were of a mild character.

At the close of Experiment I, ground limestone was fed to the pigs of the first three lots (low-calcium) for a period of 39 days. This addition to the diet effected a marked improvement in these pigs as evidenced by

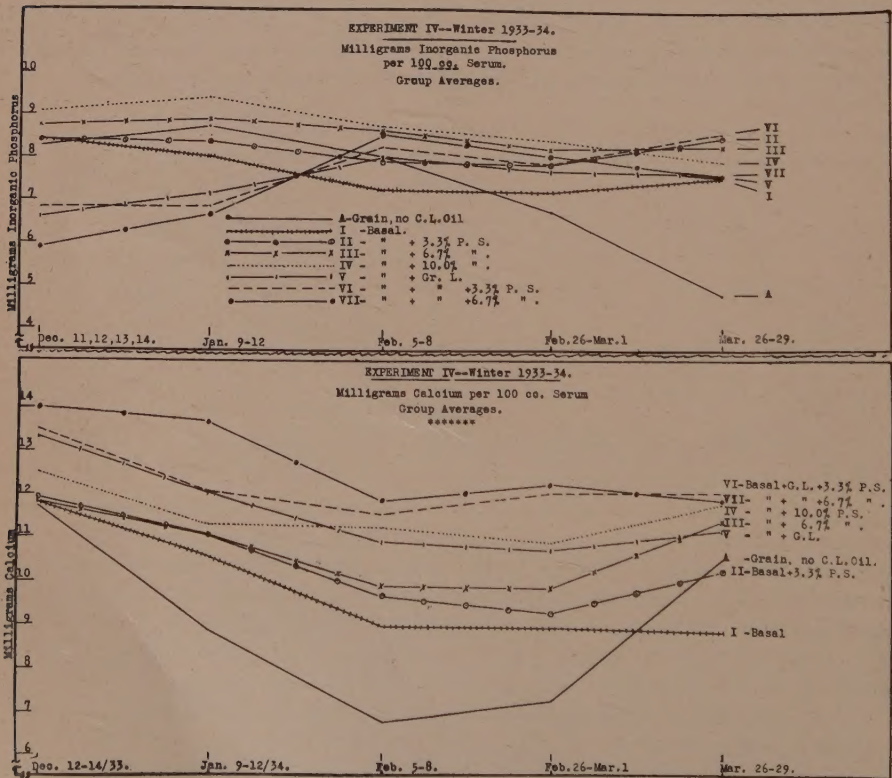


FIGURE 2. Chart showing inorganic phosphorus and calcium level of the blood serum at intervals during the progress of Experiment IV (winter 1933-34).

an increased rate of growth and a restoration of normal or nearly normal locomotory powers. A blood analysis on the 39th day showed that the blood calcium had risen to an average level of 12.8 mg. for the three lots. Similar results were obtained in Experiment IV, when ground limestone was added to the ration of the Group A pigs (See Figure 2). This group did not receive cod liver oil during the course of the trial, but even in its absence the addition of ground limestone restored the appetite of the pigs and altered their growth curve from a negative to a positive. After 25 days a blood analysis showed that the level of calcium had risen 3.3 mg. and stood at a level of 10.51 mg. per 100 cc. of blood serum. This rise in the level of calcium was accompanied by a marked improvement in locomotory ability. These results indicate that the calcium of ground limestone can be assimilated by pigs in either the presence or absence of cod liver oil, and that its assimilation was associated with a recovery from the crippled condition which existed in these low-calcium pigs.

In a discussion of the results of the inorganic phosphorus determinations, it may be stated that the results in Experiment II and perhaps in Experiment III suggest that in the low-limestone groups, a low level of blood calcium was accompanied by a high level of inorganic phosphorus. This is in agreement with the findings of Sinclair (6). On the other hand in Experiments I and IV this reciprocal relationship was not demonstrated to the same extent (See Figure 2), and a slightly subnormal inorganic phosphorus accompanied a low blood calcium. In this connection it is perhaps significant that the blood calcium in Experiments II and III, where the reciprocal relationship between calcium and phosphorus was demonstrated, stood at a level of $10 +$ mg. per 100 cc., while in Experiments I and IV the blood calcium fell to around 8 mg. This suggests that under the conditions of this trial a reciprocal relationship existed between blood calcium and phosphorus when the calcium was moderately low, but when the fall in calcium was very marked this reciprocal relationship was lost.

Phosphatase Determinations

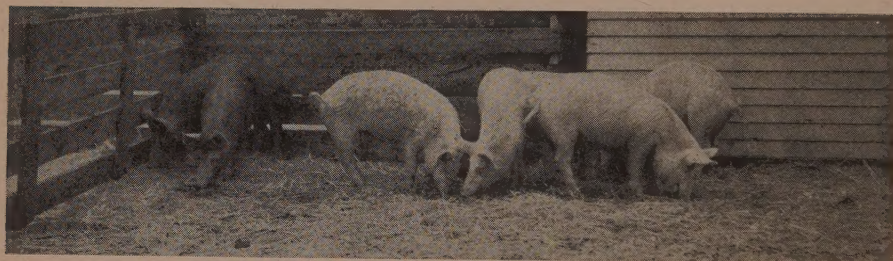
Little has been done to investigate the significance of the phosphatase content of the blood of farm animals as associated with abnormal or unsatisfactory bone development. Phosphatase is the enzyme which hydrolyses phosphoric esters such as glycerophosphate and hexose phosphate. According to Robison's (7) theory of ossification the presence of soluble organic calcium phosphates in the blood is assumed, and it is considered that the very active phosphatase present in the epiphyseal zone and periosteum plays an important part in bone formation by splitting off inorganic calcium phosphate at the sites of ossification. Kay (8) who is perhaps the outstanding authority on the subject of phosphatase makes this statement:

"In addition to the two constituents of the blood which have been known for some years to be affected to a greater or less extent in bone diseases, namely the serum calcium and inorganic phosphate, we have now a third variable—the plasma phosphatase which suffers still greater changes."

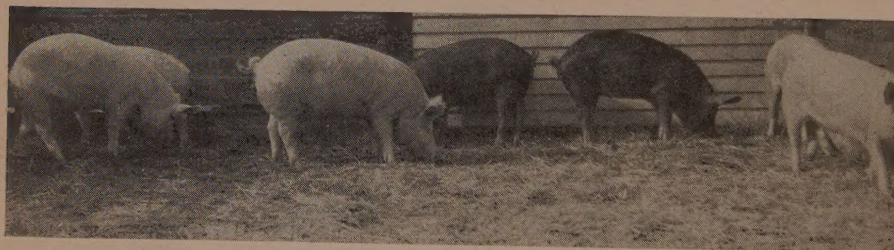
Since it has been found (9) that deep seated disturbances of bone metabolism in man and various small experimental animals are accompanied by an unusually high concentration of phosphatase in the plasma it is of



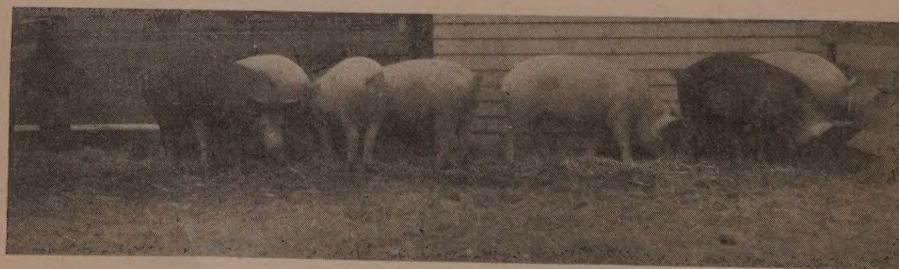
GROUP A. Grain only, no cod liver oil.



GROUP I. Basal Ration (Grain + cod liver oil).



GROUP V. Basal Ration + Ground Limestone.



GROUP VII. Basal Ration + Gr. L. + 6.7% P. S.

FIGURE 3—Representative Groups of Pigs in Experiment IV
(Winter, 1933-34)

interest to study the phosphatase level in pigs showing clinical symptoms of a lack of sufficient calcium for bone development.

In connection with Experiment IV, a cursory study was carried out on the amount of the enzyme phosphatase present in the blood of pigs exhibiting clinical signs of a deficiency of calcium for normal bone development. In making these determinations the method of Jenner and Kay (10) was followed except in one detail: viz. blood serum was used instead of blood plasma. The blood samples were drawn from the tail in the usual manner. The results obtained are presented in Table 5.

TABLE 5.—LEVEL OF BLOOD SERUM PHOSPHATASE

| Date | Group No. | Pig No. | Phosphatase | Condition of pig |
|---------|-----------|---------|-------------|---------------------------------------|
| 2/26/34 | A | 328 | 12.84 | Active. |
| 2/27/34 | A | 280 | 14.66 | Badly crippled. Unable to walk. |
| 2/28/34 | A | 336 | 9.42 | Crippled, but able to walk. |
| 3/1/34 | A | 311 | 8.04 | Crippled, some difficulty in walking. |
| 3/23/34 | I | 369 | 15.72 | Rear legs bowed, all legs stiff. |
| 3/23/34 | I | 304 | 8.82 | Stiff in hind quarters. |
| | | | 11.58 | (Average for low-calcium pigs.) |
| 3/23/34 | VII | 368 | 5.40 | Apparently normal and thrifty. |
| 3/23/34 | VII | 372 | 4.02 | Apparently normal and thrifty. |
| | | | 4.71 | (Average for high-calcium pigs.) |

It is realized that the volume of data presented is limited, but the results at least indicate that the level of phosphatase in the blood of the crippled, low-calcium pigs was definitely higher than in the apparently normal high-calcium pigs. This may be taken (9) as further evidence of a disturbance in the bone metabolism of the low-calcium pigs.

The Influence of Cod Liver Oil

In the first three experiments of the series under review cod liver oil was fed in all lots as a source of vitamins A and D. In connection with the fourth experiment it was thought well, as has already been mentioned, to include a group designated as Group A, in order to check the efficiency of the cod liver oil from the point of view of its growth promoting quality and the effect on calcium and phosphorus metabolism under conditions of a non-supplemented cereal diet.

The pigs in Group A (see Figure 3) after attaining a weight of 89.1 pounds at the end of twelve weeks on experiment became very unthrifty in appearance and their appetite was decidedly poor. At this stage these pigs were all crippled or stiff whereas this condition was not nearly as marked in Lot I, receiving a 1% allowance of cod liver oil. The average daily gain per pig for the entire period of the experiment (130 days) was 0.40 pound for Group A and 0.66 for Group I. Blood analyses during the months of December, January and February showed levels of 8.86, 6.75 and 7.21 milligrams of calcium per 100 ccs. of blood serum in Group A as

compared with levels of 10.52, 8.89 and 8.84 in Group 1, indicating that the cod liver oil was exerting an influence on the assimilation of the small amount of calcium present in the cereal ration.

CONCLUSIONS

The following conclusions may be drawn from the results of the experiments which have been reviewed in this paper:—

1. A basal ration of wheat, oats and barley supplying approximately 175 grams of digestible crude protein and 0.5 gram of calcium daily per 100 pounds live weight is inadequate for growing and fattening pigs of 50-200 lbs. live weight. Pigs fed such a ration grew slowly, became "stiff" or "crippled" and failed to make economical use of their feed.

2. The calcium of ground limestone can be assimilated by pigs. The addition of ground limestone to the basal ration led to the development of apparently normal bone and increased both the rate of growth and economy of feed utilization.

3. The beneficial effects of adding protein to the basal ration without supplying additional calcium were interfered with by the development of a condition of "stiffness" or "cripling" in the pigs.

4. The addition of ground limestone to such rations prevented the development of "stiffness," and promoted growth and more economical feed utilization.

5. Feeding a low-calcium diet led to a diminution in the amount of calcium in the blood serum. No consistent changes occurred in the level of inorganic phosphorus.

6. A low-level of calcium in the blood serum was found to be associated with the development of "stiffness" or "cripling."

7. Feeding ground limestone raised the level of calcium in the blood serum.

8. Indications were obtained that pigs exhibiting clinical symptoms of abnormal bone development due to a deficiency of calcium have a greater amount of phosphatase present in their blood than have normal pigs.

9. Cod liver oil added in the basal ration promoted growth and the assimilation of the calcium present in the grains.

10. No obvious evidence of phosphorus deficiency appeared when a ration containing approximately 0.35% of phosphorus was used.

11. Under the conditions of the experiments under review a ration containing 15% of digestible crude protein and supplying an average of approximately 250 grams (0.55 lb.) of digestible crude protein daily per 100 lbs. live weight gave the most satisfactory results.

12. A daily calcium intake of 2.30 grams (0.135% of the ration) per 100 lbs. live weight maintained an apparently normal level of calcium in the blood serum and prevented the condition of "cripling" which developed in groups on a lower calcium intake, but did not provide sufficient calcium to bring about the most efficient utilization of the feed consumed.

13. Feeding ground limestone at a level which allowed for a daily intake of from 13-15 grams of calcium (0.72%-0.86% of the ration) appeared to be excessive. The necessity for further work in connection with varying the daily intake of calcium is indicated.

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Résumé

L'ADDITION DE PROTÉINE ET DE CALCIUM À UNE RATION DE MENUS GRAINS POUR LES PORCS D'ÉLÈVE. R. D. Sinclair et L. W. McElroy, Université de l'Alberta, Edmonton, Alta.

Les résultats de l'expérience qui est passée en revue dans ce travail peuvent donner lieu aux conclusions que voici :

Une ration de base, composée de blé, d'avoine et d'orge fournissant quotidiennement à peu près 175 grammes de protéine brute digestible et 0.5 gramme de calcium par 100 livres de poids vif, est insuffisante pour les porcs d'élève et d'engrais pesant de 50 à 200 livres, poids vif. Les porcs qui recevaient cette ration profitaient lentement, ils perdaient l'usage de leurs membres et ne faisaient pas un emploi économique de leur nourriture. Les porcs peuvent s'assimiler le calcium de la pierre à chaux broyée. L'addition de pierre à chaux broyée à la ration de base a provoqué le développement d'une ossature apparemment normale, activé la rapidité de croissance et facilité l'assimilation de nourriture. Lorsque la quantité de calcium fournie était insuffisante, les effets bienfaisants de l'addition de protéine à la ration de base étaient contrecarrés par le développement d'un état désigné "raideur" ou "impotence" chez les porcs. L'addition de pierre à chaux broyée à ces rations a empêché l'apparition de cette "raideur", encouragé la croissance et causé une utilisation plus économique de la nourriture. Lorsque le régime était déficitaire en calcium, la quantité de calcium dans le sérum du sang diminuait, mais il n'y avait pas de changements correspondants dans la proportion de phosphore inorganique. Cette faible proportion de calcium dans le sérum du sang était accompagnée d'un développement de "raideur" ou "d'impotence". L'emploi de pierre à chaux broyée dans l'alimentation a relevé le niveau de calcium dans le sérum du sang. Il a été constaté que le sang des porcs qui exhibent des symptômes cliniques d'un développement anormal des os, provenant d'un manque de calcium, contient une quantité plus grande de phosphatase que celui des porcs normaux. L'huile de foie de morue ajoutée à la ration de base a activé la croissance et l'assimilation du calcium présent dans les grains. Aucune preuve évidente d'un manque de calcium n'a été constatée lorsqu'on s'est servi de rations contenant environ 0.35% de phosphore. Dans les conditions de ces expériences, une ration contenant 15% de protéine brute digestible et fournissant en moyenne 250 grammes (0.55 liv.) de protéine brute digestible quotidiennement par 100 livres de poids vif, est celle qui a donné les résultats les plus satisfaisants. Une absorption quotidienne de 2.30 grammes (0.135% de la ration) par 100 livres de poids vif a maintenu un niveau apparemment normal de calcium dans le sérum du sang et prévenu "l'impotence" qui s'est développée dans les groupes qui faisaient une plus faible absorption de calcium sans fournir cependant suffisamment de calcium pour provoquer l'utilisation la plus efficace de la nourriture consommée. L'emploi de pierre à chaux broyée à un niveau qui permettait une absorption quotidienne de 13 à 15 grammes de calcium (0.72%-0.86% de la ration) paraissait être excessif. Les résultats acquis indiquent qu'il serait nécessaire de faire de nouvelles recherches sur les variations dans l'absorption quotidienne de calcium.

FECUNDITY AND NURSING CAPACITY OF LARGE YORKSHIRE SOWS

ALAN DEAKIN AND E. B. FRASER¹

Central Experimental Farm, Ottawa

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In the spring of 1932 a project covering the collection of litter records was begun on the Dominion Experimental Farms. The objects of the experiment are as follows: first, to determine fecundity, litter mortality, and nursing capacity of brood sows, the latter characteristic being measured by the amount of gains of litters from birth to three weeks, since up to this age the litters are dependent upon their mothers' milk; secondly, to determine the variability of litters from the same sow in both size and gains; and thirdly, to determine the value of such data for rating sows and particularly boars. This paper is a report on the first phase of the work.

Source of Data

The data were obtained from the herds at Central Experimental Farm and fourteen Branch Farms located in the various Provinces of the Dominion. Considerable climatic variation exists between the various Experimental Farms; however, housing, feeding and management of brood sows are comparatively uniform, and hence litter records are reasonably comparable. Litters are born in all seasons, but the data were considered insufficient to warrant a classification by season. Moreover, Carmichael and Rice (1) found no noticeably regular influence of season on litter size or birth weight.

Procedure

The data were collected on prepared forms which called for details of sire and dam, time and date of birth of litters, number born, total weight of both live and dead pigs at birth, and the weight of litters on the 21st day after initial weighing. The initial weights were taken ten to twenty-four hours after birth, which permitted all weighings during the working day, and excluded pigs that died within a few hours after birth from the initial live weight of litters. Dates and weights of pigs that died after initial weighing were also given.

Presentation of Data

The data are presented in the accompanying table classified according to the size of litter at three weeks, together with weighted averages of all litters. The range in litter size is from four to twelve pigs per litter, giving a total of nine classes, which will be referred to as the four class, five class, etc. There were a few litters of under four and over twelve pigs per litter alive at three weeks, but insufficient to warrant presentation. For comparative purposes the litter weights are given on a pig basis.

Number of Litters

There is a total of 410 litters, all of which are pure-bred Yorkshires. Of those alive at three weeks the nine class has the most with 75 litters. From the nine class the number of litters decrease very uniformly down to the six and up to the twelve class, indicating a normal distribution between these two numbers.

¹ Geneticist and Acting Chief Assistant respectively in the Division of Animal Husbandry.

TABLE 1.—LITTER DATA AVERAGES OF 410 YORKSHIRE LITTERS CLASSIFIED ACCORDING TO THE NUMBER ALIVE PER LITTER ON THE 21ST DAY AFTER BIRTH

| Number born | Number of pigs alive 21st day | Birth weight | Weight 21st day | Average gains | C.V. of litter gains | Number of mammae per sow | Number of litters |
|-------------|-------------------------------|--------------|-----------------|---------------|----------------------|--------------------------|-------------------|
| 8.5 | 4 | 2.92 | 11.74 | 8.83 | 30.26 | 11.9 | 15 |
| 10.4 | 5 | 2.85 | 11.22 | 8.37 | 22.45 | 11.9 | 27 |
| 10.3 | 6 | 2.71 | 11.30 | 8.59 | 20.15 | 12.2 | 29 |
| 10.9 | 7 | 2.84 | 11.29 | 8.45 | 19.86 | 11.8 | 55 |
| 12.0 | 8 | 2.70 | 10.80 | 8.10 | 19.70 | 12.3 | 64 |
| 12.1 | 9 | 2.72 | 11.04 | 8.32 | 19.60 | 12.3 | 75 |
| 12.8 | 10 | 2.67 | 10.49 | 7.82 | 20.00 | 12.5 | 62 |
| 13.4 | 11 | 2.77 | 10.89 | 8.12 | 21.48 | 12.7 | 53 |
| 14.4 | 12 | 2.46 | 10.14 | 7.68 | 24.35 | 13.7 | 30 |
| 12.0 | Wt. aver. 8.5 | 2.68 | 10.87 | 8.19 | 20.92 | 12.3 | |

Number of Mammae per Sow

The number of mammae recorded were those functioning at the time of farrow. As would be expected the number per sow does not vary very much, since it is a general practice in selecting gilts for breeding to pay particular attention to this characteristic. However, the data presented show an increase in the average number of mammae from 11.9 in the four and five classes to 13.7 in the twelve class. In the ten and up classes the average number of pigs born exceeded the average number of functioning mammae. With regard to the inheritance of this characteristic Wentworth (8) has shown that there is correlation of $.2626 \pm .028$ between the number of mammae of dams and offspring, while there is also a tendency of "triangle" and "suppressed" nipple variations to be transmitted. Wentworth and Lush (9) found that in crosses between wild boars and domestic sows the progeny tended to inherit the smaller number of mammae of the wild parents.

Number Born and Number Alive at Three Weeks

The Yorkshire breed has a reputation for prolificacy which is borne out by the records of these 410 litters. The average number born per litter is 12.0, with the range of 8.5 for the four class to 14.4 for the twelve class. The average number alive at three weeks is 8.5, a mortality of 29.2%. This mortality is greatest in the smaller litter classes, being over 50% in the four and five classes. Many of the pigs were born dead, others were weaklings and were killed. Some litters were too large for the sows to raise and thus some of the less vigorous ones were killed. There were also several accidental deaths.

Birth weight

In the majority of litters one or more pigs died between the time the birth weight was taken and the three-week weight; hence, the weight of those that died had to be deducted from the initial litter weight. This was done by deducting the actual weight of dead pigs when this was less than the average birth weight of the litter, and the average birth weight was deducted when the dead weight was greater than the average weight.

The birth weights correspond fairly closely to those given by Lush, Hetzer, and Culbertson (7) for American data, except that they are slightly heavier, largely due, probably, to the fact that for the present records the pigs were weighed ten to twenty-four hours after birth, and had, therefore, all been suckled. It can be noted that the birth weights gradually decrease, with slight variations, with the number born. In the four class with an average of 8.5 pigs born the average weight of the live pigs is 2.92 lb., while in the twelve class, with 14.4 pigs born, the birth weight is 2.46 lb.

The weight of the pigs born dead is not given because of the tendency of recorders to weigh in pounds and half pounds, which would thus give a large error when only one or two pigs are weighed. Lush et al (*loc. cit.*) found this tendency also in the records studied by them. These workers report, however, a lighter weight for pigs born dead, most likely owing to many of the pigs born dead having died several days before birth. They also found a slight sex difference, the males being slightly but significantly heavier than the females.

Weight Increase and Variation

As would be expected the three-week weight is larger for the smaller litters, there being a difference of 1.6 lb. between the four and the twelve classes. This difference shows up also in the gains, though to a slightly less extent. The average gains do not decrease quite uniformly from the four to the twelve class, which may be accounted for by the large variation there is in gains per litter. The greatest discrepancy is between the number nine, ten, and eleven classes. From the standpoint of the total weight of litters at three weeks the twelve class is the greatest, with 121.08 lb. per litter as against 119.79 lb. for the eleven class.

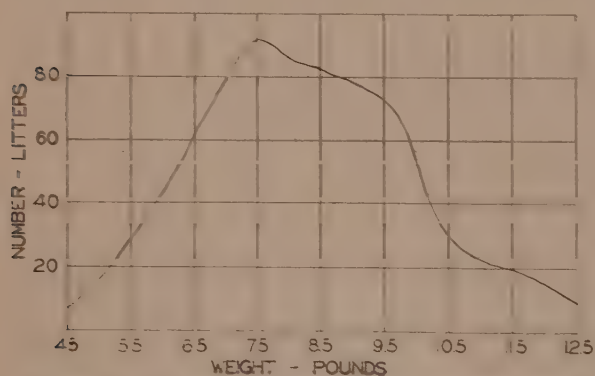


FIGURE 1. Distribution of gains per litter from birth to three weeks on a pig-per-litter basis.

The coefficient of variation was calculated from the pounds gain per litter from birth to three weeks. The average C.V. is 20.92% and there is little variation between the classes except in the twelve, and especially the four class. This is somewhat contrary to expectation as sows with smaller litters would be expected to give good and uniform

gains. However, within the smaller litter classes are the poor lactating sows and unthrifty or weakling pigs, many of which die off before three weeks.

In order to present more clearly the variability in litter growth, the gains per pig per litter are presented graphically. There are 408 litters plotted, two extremes having been omitted that are included in the table, one a 3 lb. and the other a 15 lb. gain. As can be noted, the variations in gains are from 4.5 lb. to 12.5 lb. with a modal gain of 7.5 lb. per pig per litter.

Age of sows

The average age of the 410 sows was approximately 3.3 years at farrow. There was little variation in the average age of the different classes, except between the four and five classes, their respective ages being approximately 2.3 and 4.0 years. The age of sows is one of the factors which affects both birth weight and litter size. Thus Carmichael and Rice (1) found a fairly general increase in the birth weight of pigs as the sows grew older, while litter size only increased with the age of sows up to about three years. In a later study of the same herd Keith (5) found that in general the size of the litter increased with the age of the dam up to about 4.5 years, after which a gradual decrease occurred. Ellinger (2) found from a group of 134 sows of native Danish breed, each of which had ten litters, that the size of litters increased up to the sixth and seventh litter.

Time of Farrowing

Since the hour at which each sow farrowed was recorded it is of passing interest to mention some of the data. Only 19% of the sows farrowed between 7.00 A.M. and 2.00 P.M. The largest number farrowed late at night, 31% farrowing between 7.00 P.M. and midnight, and 73% between 2.00 P.M. and 4.00 A.M.

DISCUSSION

The records of these 410 litters show a large variation in the nursing capacity of sows as measured by the gains of litters to three weeks. For the more economical production of litters sows should be selected which raise litters of from nine to twelve pigs of average and above average gains. Improvement and maintenance of prolificacy and good nursing capacity depend, however, upon good breeding, feeding and management practices. As Hammond (3) points out, fecundity depends upon (a) the number of eggs shed which is mainly a matter of internal nutrition, although age is also a factor; (b) the number fertilized, which may be influenced by partial sterility of the boar; and (c) the number that develop properly, which mostly depends upon both nutritional and genetical factors. The time of service is considered to be an important factor in obtaining high fecundity. Krallinger and Schott (6), however, found insignificant differences in both litter size and percentage of fertile matings of early compared with late matings. In 46 sows served during the first few hours after the onset of heat, and 348 served mostly the following day, the litter size was respectively 9.8 and 10.05, and the percentage of fertile matings 63.0 and 65.8.

On a statistical investigation of the Large White breed in Sweden, Johansson (4) found that the correlation between litter size from the same sows was very low and insignificant. He concludes that sows should be selected on the basis of their having fourteen functional mammae and giving good litter gains, and secondarily upon litter size. Keith (5) however, found a significant correlation between the size of a given litter and the size of succeeding litters if a large enough number of individuals were used. It would appear, therefore, that the most effective way of identifying strains of high fecundity and good nursing capacity would be through progeny testing several daughters of each sire for these characteristics rather than placing too much emphasis on an individual sow's record. With the accumulation of more litter data the value of such a practice may be tested.

SUMMARY

1. Litter data is presented of 410 Yorkshire litters classified according to the number alive at three weeks, the range being from four to twelve pigs per litter.

2. The average number of functioning mammae of sows at farrow was 12.3; the number of pigs born 12.0; alive at three weeks 8.5; birth weight 2.68 lb.; weight on 21st day 10.87 lb.; and C.V. of gains from birth to three weeks 20.92%.

3. The number of mammae increased slightly and the average number of pigs born considerably from the four to the twelve class, while the average weights and gains decrease slightly, though not quite uniformly, from the four to the twelve class.

4. The problem of recognizing and selecting prolific strains of pigs is briefly discussed.

ACKNOWLEDGMENTS

For the collection of litter records acknowledgment is hereby made of the kind co-operation of the respective superintendents of the Experimental Farms and Stations located at Nappan, and Kentville, N.S.; Fredericton, N.B.; Cap Rouge, Ste. Anne de la Pocatiere, and La Ferme, Que.; Kapuskasing, Ont.; Brandon, Man.; Scott and Indian Head, Sask.; Lethbridge, and Lacombe, Alta.; Windermere, and Agassiz, B.C.

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Résumé

FÉCONDITÉ ET CAPACITÉ D'ALLAITEMENT DE GROSSES TRUIES YORKSHIRES. Alan Deakin et E. B. Fraser, Ferme expérimentale centrale, Ottawa.

Les données présentées couvrent 410 portées Yorkshires classées d'après le nombre de gorettes en vie à l'âge de trois semaines, nombre qui variait de 4 à 12 sujets par portée. Le nombre moyen de trayons en fonctionnement chez les truies au moment de la mise-bas était de 12.3; le nombre de porcs nés, de 12.0; en vie, à trois semaines 8.5; poids à la naissance 2.68 liv.; poids au 21ème jour 10.87 liv.; et coefficient de variation de l'augmentation de poids à partir de la naissance jusqu'à l'âge de trois semaines, 20.92%. Le nombre de trayons augmentait légèrement tandis que le nombre moyen de porcs nés augmentait considérablement à partir de la classe de 4 sujets jusqu'à celle de 12; d'autre part, les poids moyens et les augmentations moyennes de poids diminuaient légèrement, mais non pas d'une façon très uniforme, à partir de la classe de 4 sujets jusqu'à celle de 12. Le problème de l'identification et du choix des espèces prolifiques de porcs est discuté sommairement.

THE EFFECT OF FULL VERSUS LIMITED FEEDING ON THE PROTEIN LEVEL REQUIRED IN THE HOG RATION¹

E. W. CRAMPTON²

Macdonald College, P.Q. (McGill University)

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INTRODUCTION

The question of the optimum level of protein in the diets of hogs intended for bacon production is one on which investigators differ. That rate of growth and economy of feed may be adversely affected by too meagre a protein intake is generally admitted. The possibility, however, that the protein requirements of pigs may in some measure be correlated with total food intake, and hence that under full feeding the proportion of protein to carbohydrate equivalent may be different to that which is optimum where limited feeding is followed, has not been investigated. And since most of the hog feeding of eastern Canada would be classed as "limited," while the majority of feeding trials on which hog feeding recommendations are based have involved full feeding, it seemed advisable to obtain information as to whether or not this difference in feeding practice would need to be taken into account in interpreting results. Accordingly, a feeding trial was undertaken in July, 1933, the results of which are herein reported.

The object of the experiment was to study the effects on rate of gain in live weight, and on the type of hog and hog carcass produced by different levels of protein in the diet when full fed as compared to limited feeding.

METHODS

Plan

The allotment of pigs to the several feeding lots in so far as the protein levels were concerned was a matter of standard routine. With regard to the full and limited feeding, it was decided to pair the pigs at allotment, one pig of each pair to be full-fed while the pair mate was to receive at each feeding half the quantity given the full-fed pig. Thus the consumption of the full-fed pig became the gauge for what was to constitute limited, or half feeding.

Allotment

Forty Yorkshire pigs were grouped at weaning time into 20 pairs, so that considering weight, condition, thrift, age, breeding, and sex, the pair mates were as nearly alike as possible. The ages ranged from 59 to 62 days. Out of the 20 pairs, six were not of the same sex and seven were not litter-mates. All were sired by the same boar, and the dams were sisters or half-sisters. In no case did pair mates differ by more than four pounds in initial weight (see Table 1).

Once the pairings were made, the pairs were allotted at random to each of the five lots. The subsequent separation of the pair mates of a lot into the sub-lot groups as 1 or 1a, 2 or 2a, etc., was determined by flipping a coin.

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² Associate Professor of Animal Husbandry.

This allotment procedure was followed (1) in order to obtain a random allotment between and within lots receiving rations of different protein levels, and (2) at the same time to preserve as close a similarity as possible between half and full-feed pair mates.

Rations Fed and Feeding Practice

All pigs were individually penned and hand fed throughout the trial. The dry meal allowance was measured into the trough and the water allowance poured over it.

The composition of the basal ration and of the protein-mineral supplement was the same for all lots throughout the trial. The former consisted of equal parts of corn (or hominy) and barley. The supplement was compounded as follows:—

40.0 lb. Tankage
20.0 lb. Linseed oilmeal
20.0 lb. Fishmeal
12.5 lb. Bone char
4.0 lb. Wood charcoal
1.0 lb. Cod liver oil
2.0 lb. Salt
0.5 lb. Ferric oxide

100 lbs.

This supplement carried 43.4% protein. The charcoal was included only as a carrier for the cod liver oil.

The proportion of the basal and supplement fractions of the rations differed between each of the five lots, not only at the start of the trial but during the successive feeding periods. These periods were as follows:—

Weanling period—first 30 days of the test.

Growing period—second 30 days of the test.

Fattening period—third 30 days of the test.

TABLE 1.—DETAIL OF RATIONS FED BY PERIODS AND INITIAL WEIGHTS OF PIGS AS ALLOTTED

| Lot | Percent protein supplement in rations | | | Level of feeding | Live weights of pigs at allotment | | | | |
|-----|---------------------------------------|----------------|------------------|------------------|-----------------------------------|----|----|----|------------------|
| | Weanling period | Growing period | Finishing period | | Pigs | | | | Average of group |
| | | | | | 1 | 2 | 3 | 4 | |
| 1 | 30 | 20 | 10 | Full | 23 | 49 | 42 | 32 | 36.5 |
| 1a | | | | Half | 22 | 47 | 42 | 32 | 35.8 |
| 2 | 30 | 10 | 10 | Full | 25 | 27 | 27 | 31 | 27.5 |
| 2a | | | | Half | 25 | 27 | 27 | 31 | 27.5 |
| 3 | 20 | 20 | 10 | Full | 27 | 30 | 30 | 38 | 31.3 |
| 3a | | | | Half | 23 | 29 | 28 | 37 | 29.3 |
| 4 | 20 | 10 | 10 | Full | 25 | 33 | 30 | 31 | 29.8 |
| 4a | | | | Half | 26 | 30 | 30 | 30 | 29.0 |
| 5 | 10 | 10 | 10 | Full | 19 | 35 | 27 | 33 | 28.5 |
| 5a | | | | Half | 19 | 41 | 26 | 34 | 30.0 |

Table 1 gives the detail of the proportions of protein supplement in the rations of the several lots for each feeding period.

Gains of pigs and their feed consumptions were recorded for each of these 30-day periods. Where necessary to extend the feeding period beyond the 90 days, the rations of the fattening period were continued. In this trial all lots remained on feed an extra 14 days.

After this time (104 days of feeding) all full-fed pigs (excepting one at 187 lbs.) had reached 190 lbs. or more, and were, therefore, removed from test. The removal of the full-fed pigs removed the guides for what constituted "half feed." Consequently, the remaining pigs were then full fed to market weight.

Statistical Reduction of Data

The allotment of animals and organization of the trial was so done that the data could be analysed statistically, using the method of partial regression² to correct the observed gains in weight for the effects of differences in the initial weights of the animals at the start of any feeding period and for the effects of differences in feed intake. This procedure makes possible the best estimate of gains to be expected had all animals been of equal weight at the beginning of the feeding and had they eaten equal quantities of feed. Hence, gains so adjusted will, within the limits of experimental error, be a direct expression of the efficiency of the respective rations on which they were produced.

In Tables 2a, 3a, and 4a, the relative gains shown are based on the general mean gain of all lots during the period in question. These figures represent the relative efficiency of the several rations in producing live weight increases on pigs according to the percentage protein of the rations and the level of feed intake (full versus half fed).

Observations During the Trial

After from three weeks to a month of feeding, three of the pigs showed signs of diarrhoea and the faeces of several others were quite soft. The three pigs and their pair mates were removed from the trial and replaced with other pairs. One of the replacements (Lot I, pig No. 15) later suffered from diarrhoea so that the data from that pair were deleted from the trial.

This condition could not be explained unless it was the result of the cod liver oil in the rations. It could not have been connected with protein level or with full or half feeding, since the symptoms (soft faeces) occurred as often in one group as another. Furthermore, the same feeds excepting the cod liver oil had been fed for several years without such symptoms occurring. There did not appear to be any inflammation or irritation, and the faeces though soft were of normal color. The pigs seldom went off feed. In all cases, excepting the four above mentioned, the condition cleared up after two or three weeks.

RESULTS

The presentation of the results of this study will be more clearly made if each period is first considered by itself. For complete data the reader is referred to the appendix.

² See Crampton and Hopkins. The use of the method of partial regression in the analysis of comparative feeding trial data. Part I. J. Nutrition, 8 : 1. July, 1934. Part II. J. Nutrition, 8 : 3. September, 1934.

Throughout this report references to protein level are in terms of the proportions of the mixed protein-mineral supplement to basic feeds. In terms of total crude protein ($N \times 6.25$) of the complete diets, the equivalents are as follows:

- 30% protein supplement gave a ration carrying 20% crude protein.
- 20% protein supplement gave a ration carrying 17% crude protein.
- 10% protein supplement gave a ration carrying 14% crude protein.

Weanling Period (First 30 Days from Weaning)

The actual average daily gains made during the weanling period by the pigs, and the relative gains, to remove effects of differences in initial weight of pig and unequal feed intake, are given in Table 2.

TABLE 2.—AVERAGE RATE OF GAIN (IN LBS.)—WEANLING PERIOD (30 DAYS)

| Lots | | I | II | III | IV | V | Average half and full feed |
|---------------------------------|----------|------|------|------|------|-----|----------------------------------|
| Protein supplement in ration, % | | 30 | 30 | 20 | 20 | 10 | |
| Average daily gain | Full fed | 1.02 | 1.16 | 1.06 | 1.23 | .83 | 1.06 |
| | Half fed | .69 | .72 | .70 | .67 | .42 | .64 |

TABLE 2A.—RELATIVE GAIN (IN LBS.) ADJUSTED TO EQUAL FEED INTAKE AND CONSTANT INITIAL WEIGHT OF PIG

| Lots | | I | II | III | IV | V | Average half and full feed |
|---------------------------------|----------|-----|-----|-----|-----|----|----------------------------------|
| Protein supplement in ration, % | | 30 | 30 | 20 | 20 | 10 | |
| Relative gains | Full fed | 103 | 116 | 98 | 113 | 76 | 101 |
| | Half fed | 109 | 104 | 102 | 100 | 78 | 99 |

Rate of Gain

In so far as the rate of gain is concerned, it is at once evident that full feeding resulted in about 60% faster gains than half feeding, regardless of level of protein of the diet. In judging the effect of protein level, Lots I and II should be averaged, since both were on rations containing the same percentage of protein supplement. Similarly, Lots III and IV must be taken together. Between Lots I, II, III, and IV, there was practically no difference with the half-fed pigs. Lot V, however, in which the protein supplement constituted but 10% of the ration during the weanling period, showed markedly slower gains.

With the full feeding it appears that the 20% supplement lots (Lots III and IV) had a slight advantage over the 30% supplement rations (Lots I and II). As with the limited feeding, the pigs in Lot V gained decidedly slower than those of the other groups on the same feeding practice.

Efficiency of Ration

The relative efficiency of the several rations fed cannot be directly measured by the rate of gain made by the pigs, since these gains are

materially affected by the quantity of feed eaten and to a lesser extent by the initial weights of the pigs. In order to eliminate these two factors, the actual gains were corrected statistically for differences in feed intake and varying initial weight and then expressed as a percentage of the general average gain of all lots. These relative gains are directly comparable and represent the best estimate obtainable from the data of the relative nutritive values of the rations fed.

When presented in this way, it becomes clearly evident that no differences can be claimed between half and full feeding in so far as efficiency of the rations is concerned, and this regardless entirely of level of protein intake. In other words, no increased efficiency of the nutrients of the rations is realized by limited as compared to full feeding during the weanling period.

In the matter of protein level, there appears to be no significant difference between the rations carrying 30% and those consisting of 20% protein supplement. Lot V, however, in which the mixture contained but 10% protein supplement, showed significantly ($P = .05$) smaller gains per unit feed eaten. The difference is quite clear cut. In so far as the weanling period is concerned, therefore, it would appear that with the protein supplement used in this study, this fraction of the ration need not exceed 20% but should be larger than 10%. (Equivalent to 17% and 14% crude protein respectively).

Growing Period (Second 30 Days from Weaning)

The data for the second 30 days of feeding have been recorded and analyzed independently by the same methods described for the weaning period. The results are shown in Tables 3 and 3a.

TABLE 3.—AVERAGE RATE OF GAIN (IN LBS.)—GROWING PERIOD (30 DAYS)

| Lots | | I | II | III | IV | V | Average half and full feed |
|---------------------------------|----------|------|------|------|------|------|----------------------------------|
| Protein supplement in ration, % | | 30 | 10 | 20 | 20 | 10 | |
| Average daily gain | Full fed | 1.69 | 1.55 | 1.86 | 1.92 | 1.48 | 1.70 |
| | Half fed | 1.06 | .99 | 1.34 | 1.06 | .92 | 1.07 |

TABLE 3A.—RELATIVE GAIN (IN LBS.) ADJUSTED TO EQUAL FEED INTAKE AND CONSTANT INITIAL WEIGHT OF PIG

| Lots | | I | II | III | IV | V | Average half and full feed |
|---------------------------------|----------|-----|----|-----|-----|-----|----------------------------------|
| Protein supplement in ration, % | | 30 | 10 | 20 | 10 | 10 | |
| Relative Gains | Full fed | 95 | 86 | 101 | 103 | 92 | 95 |
| | Half fed | 103 | 95 | 119 | 106 | 105 | 105 |

It will be noted, however, that for this period the proportions of protein supplement have been reduced in all lots excepting Lots III and V, in which they have remained the same as in the previous period.

Rate of Gain

The daily gains (Table 3) of the full-fed pigs are, on the average, 59% faster than those of the half-fed groups. The pigs in Lots III and IV, full-fed, appear to have made somewhat more rapid progress than the others. These lots were previously both on diets containing 20% supplement. It is possible that the reduction from 30% to 20% in Lot I and to 10% in Lot II was drastic enough to have caused a check in the gains of these lots as compared to Lot III, which remained on 20% supplement. On the other hand, the reduction in supplement from 20% to 10% in the case of Lot IV did not reduce the gains in this lot over those of Lot III. Furthermore, in the half-fed groups, while Lot III is still the best, the gains in Lot I are the same as in Lot IV. Lot V, as during the weanling period, made slowest gains of all.

Efficiency of Rations

When corrections for variations in initial weight of pigs (which now, because of the intervention of the 30-day weanling period between the original allotment and this feeding period, was considerable), and differences in quantity of feed eaten, the relative standing of the groups is somewhat different (Table 2a). Lots III and IV, which started on 20% supplement, are in the first place, while Lot V is about the same as Lots I and II. Also the half-fed pigs of all lots made slightly more efficient use of their rations than did the full-fed pigs. Statistically the half-fed group of Lot III was significantly higher than any other group. The other differences were not significant as measured by odds of 20 to 1.

Fattening Period (Third 30 Days after Weaning)

Rate of Gain

Data for the third 30 days of feeding, during which the rations for all lots were reduced to 10% of supplement, are shown in Tables 4 and 4a. Again the full-fed pigs gained about 60% faster than their half-fed pair mates. The gains in the different lots, however, were quite similar during this period.

TABLE 4.—AVERAGE RATE OF GAIN (IN LBS.)—FATTENING PERIOD (30 DAYS)

| Lots | | I | II | III | IV | V | Average half and full feed |
|---------------------------------|----------|------|------|------|------|------|----------------------------------|
| Protein supplement in ration, % | | 10 | 10 | 10 | 10 | 10 | |
| Average daily gain | Full fed | 2.19 | 2.09 | 2.07 | 2.29 | 2.03 | 2.13 |
| | Half fed | 1.30 | 1.38 | 1.29 | 1.37 | 1.38 | 1.32 |

TABLE 4A.—RELATIVE GAIN (IN LBS.) ADJUSTED TO EQUAL FEED INTAKE AND CONSTANT INITIAL WEIGHT OF PIG

| Lots | | I | II | III | IV | V | Average half and full feed |
|---------------------------------|----------|-----|-----|-----|-----|-----|----------------------------------|
| Protein supplement in ration, % | | 10 | 10 | 10 | 10 | 10 | |
| Relative gains | Full fed | 104 | 102 | 99 | 106 | 108 | 104 |
| | Half fed | 94 | 98 | 94 | 98 | 98 | 96 |

Efficiency of Ration

When corrected for initial weight and feed intake, there was not a significant difference found either between half and full feeding or between lots. On the average the full-fed pigs made slightly more efficient use of the rations.

Total Feeding Period (104 Days)

As already mentioned, in order to bring the full-fed pigs to market weight an additional 14 days of feeding beyond the three 30-day periods, already discussed, was necessary, thus giving a total of 104 days. The data for the total period (104 days) are summarized in Tables 5 and 5a.

TABLE 5.—AVERAGE RATE OF GAIN—ALL PERIODS (104 DAYS)

| Lots | | I | II | III | IV | V | Average half and full feed |
|--------------------|----------|------|------|------|------|------|----------------------------------|
| Average daily gain | Full fed | 1.72 | 1.67 | 1.72 | 1.88 | 1.54 | 1.71 |
| | Half fed | 1.05 | 1.07 | 1.14 | 1.08 | .93 | 1.02 |

TABLE 5A.—RELATIVE GAIN ADJUSTED TO EQUAL FEED INTAKE AND CONSTANT INITIAL WEIGHT OF PIG

| Lots | | I | II | III | IV | V | Average half and full feed |
|----------------|----------|-----|-----|-----|-----|----|----------------------------------|
| Relative gains | Full fed | 101 | 96 | 97 | 104 | 96 | 99 |
| | Half fed | 102 | 100 | 105 | 102 | 97 | 101 |

Rate of Gain

As to full and half feeding, we find some 67% faster gains with the full feeding. The slowest gains in both full and half-fed groups were made by Lot V, which remained throughout on the 10% protein supplement. Attention might also be called to the very satisfactory rates of gain made by the full-fed pigs, averaging as they did 1.71 lbs. per day. Even the pigs of Lot V made better than one and a half pound per day gain. The limited feeding resulted in just about one pound gain per day, which is close to the average results reported under farm conditions.

Efficiency of Ration

When placed on a relative basis and the effects of feed intake and initial weight removed, there is no appreciable difference shown between full and half feeding in gains per unit feed eaten. Nor did there appear to be any difference between Lots I, II, III, or IV as the result of the different levels of protein intake. There was, however, just a suggestion that the diet of Lot V, which included 10% protein supplement throughout the 104 days, was slightly less efficient than that of the other lots. Statistically none of these differences could be counted significant.

Market Grading

As mentioned previously, after 104 days of feeding, the full-fed pigs were practically ready for market. When these pigs were removed the remaining groups were put on full feed. An attempt was made to market all pigs as they were finished. It was not possible, however, to arrange for shipment or slaughter of pigs individually, and hence some variations were unavoidable in shipping weights. The average days each lot was on feed, the shipping weights, and the live grading of the hogs on the market are shown in Table 6.

TABLE 6.—SUMMARY OF MARKET GRADING ON HOOF

| Lot | Percent protein supplement by periods | Grading on hoof | | | | | | | | | | | |
|-------------------|---------------------------------------|-----------------|------------|-----------|-----------|---------|--------------|---------------|------------|-----------|-----------|---------|--------------|
| | | Full-fed pigs | | | | | | Half-fed pigs | | | | | |
| | | No. pigs | No. Select | No. Bacon | No. Heavy | Av. wt. | Days on feed | No. pigs | No. Select | No. Bacon | No. Heavy | Av. wt. | Days on feed |
| 1 | 30-20-10 | 3 | 3 | — | — | 211 | 108 | 3 | 1 | 1 | 1 | 227 | 145 |
| 2 | 30-10-10 | 4 | 2 | 2 | — | 204 | 107 | 4 | 2 | 2 | — | 218 | 133 |
| 3 | 20-20-10 | 4 | 4 | — | — | 217 | 107 | 4 | 2 | 2 | — | 213 | 134 |
| 4 | 20-10-10 | 3 | 2 | — | 1 | 232 | 108 | 3 | 1 | 1 | 1 | 233 | 135 |
| 5 | 10-10-10 | 4 | 2 | 1 | 1 | 213 | 122 | 3 | 2 | 1 | — | 213 | 172 |
| Av. (in per cent) | | | 68.8 | 18.8 | 12.5 | 214 | 110.5 | | 47.0 | 41.2 | 11.8 | 220 | 142.6 |

It should be mentioned that two pigs from Lot III and one from Lot V were kept for breeding; one pig, Lot I, died during the trial, thus eliminating his mate on half feed; and one pair in Lot IV became mixed and was, therefore eliminated. These pigs were not included in the marketing data.

From Table 6, it is evident that full feeding did not result in any penalty as to type of pig as indicated by classification into "selects," "bacons," or "heavies." There were 13 selects, 3 bacons and 2 heavies in the full-fed group as against 8 selects, 7 bacons, and 2 heavies among the half-fed lots.

Further evidence that full feeding does not adversely affect the finished product is shown in the rail grading record and the measured carcass length (1st rib to aich bone). These data are given in Table 7.

Attention might be directed to the fact that neither the rations nor the level of feeding had the slightest effect on the length of the pig. Nor did full feeding result in a lower percentage of the carcasses grading as Wiltshires. In the case of the half-fed pigs the fact that, because of greater irregularity in reaching market condition, they were fed to slightly heavier weights on the average probably accounts for the poorer showing in the rail grading.

TABLE 7.—AVERAGE LENGTH OF CARCASS AND PERCENT WILTSHIRE SIDES

| Lot | Percent protein supplement by periods | Average length (inches) 1st rib to aich bone | | Percent Wiltshire* | |
|---------|---------------------------------------|---|----------|--------------------|----------|
| | | Full-fed | Half-fed | Full-fed | Half-fed |
| 1 | 30-20-10 | 31.8 | 31.6 | 100 | 66 |
| 2 | 30-10-10 | 32.3 | 33.0 | 100 | 50 |
| 3 | 20-20-10 | 31.8 | 32.4 | 100 | 50 |
| 4 | 20-10-10 | 33.0 | 32.3 | 100 | 33 |
| 5 | 10-10-10 | 32.9 | 32.2 | 75 | 66 |
| Average | | 32.4 | 32.4 | 93.7 | 52.9 |

*Rail grading by Wilsil Company.

SUMMARY AND CONCLUSIONS

In this trial comparisons were made between the rate of live weight gains, ration efficiency, and excellence of market hog produced by full feeding versus half feeding with rations containing different proportions of a mixed protein-mineral supplement, the latter being reduced periodically according to the plan shown in Table 8. This table also summarizes by lots and feeding periods the gains and gains corrected to constant feed intake and initial weights. In each lot half the pigs were full fed and the remainder fed half the amount eaten by the full-fed section. The results of the trial would seem to justify the following conclusions.

1. Using the feed mixtures reported in this test, the rations for market pigs for the first 30 days after weaning need not contain more than 17% total crude protein, regardless of whether pigs are full or half fed. (Lots III and IV.)

2. During the next 30 days the crude protein level of the ration under full feeding may be reduced to 14% (Lot IV). Under half feeding there is some evidence to suggest that faster gains and slightly greater feed efficiency may be expected if the protein level of the weanling period (17%) is continued through this second 30 days (Lot III).

3. After the first 60 days, all lots were fed rations carrying 14% of crude protein. The group (Lot IV) which started at weaning on the ration containing 17% of protein and changed after 30 days to a ration of 14% protein continued to show equally efficient and at the same time the fastest gains of any.

4. Over the whole period, weaning to market weight, the Lot IV, full-fed pigs, showed the best results. With half feeding, Lot III stood first by a slight margin over Lot IV.

5. A ration for weanling pigs containing only 14% crude protein does not contain sufficient protein for optimum growth. (Lot V.)

6. The efficiency of the rations in producing live weight gains was not affected by half versus full feeding. Full feeding, however, resulted for all periods and in all lots in 60% faster gains.

7. When marketed at the same live weight (about 200 lbs.), full feeding did not adversely affect the market grading either on the hoof or on the rail. There was actually a larger percentage both of "selects" and of Wiltshire sides from among the full-fed than half-fed hogs.

TABLE 8.—MEAN GAINS AND GAINS CORRECTED FOR VARYING FEED INTAKE AND INITIAL WEIGHT

| Lot No. | Percent crude protein in diets by periods | | | Level of feeding | Weanling period 1st 30 days | | Growing period 2nd 30 days | | Finishing period 3rd 30 days | | Total period 104 days | |
|--|--|----------------|----------------------|------------------------|--------------------------------|---------------------|-------------------------------|---------------------|---------------------------------|---------------------|----------------------------|---------------------|
| | 1st 30 days | 2nd 30 days | Balance of period | | Average daily gains | Corrected gains* | Average daily gains | Corrected gains* | Average daily gains | Corrected gains* | Average daily gains | Corrected gains* |
| I | 20 | 17 | 14 | Full Half | 1.02 .69 | 26.3 27.9 | 1.69 1.06 | 39.5 42.8 | 2.19 1.30 | 54.1 48.6 | 1.72 1.05 | 145.0 146.7 |
| II | 20 | 14 | 14 | Full Half | 1.16 .72 | 29.6 26.5 | 1.55 .99 | 35.8 39.7 | 2.09 1.38 | 53.0 50.6 | 1.67 1.07 | 138.1 142.7 |
| III | 17 | 17 | 14 | Full Half | 1.06 .70 | 24.9 26.1 | 1.86 1.34 | 41.9 49.5 | 2.07 1.29 | 51.5 48.5 | 1.72 1.14 | 139.5 150.6 |
| IV | 17 | 14 | 14 | Full Half | 1.23 .67 | 28.9 25.6 | 1.92 1.06 | 43.0 44.1 | 2.29 1.37 | 54.7 50.6 | 1.88 1.08 | 148.7 145.9 |
| V | 14 | 14 | 14 | Full Half | .83 .42 | 19.5 19.9 | 1.48 .92 | 38.3 41.7 | 2.03 1.28 | 56.1 50.7 | 1.54 .93 | 138.4 138.9 |
| Mean feed (all lots) Standard errors of corrected gains | | | | | 71.1 lbs. ± 4.00 lbs. | | 125.5 lbs. ± 4.53 lbs. | | 172.8 lbs. ± 6.42 lbs. | | 463.2 lbs. ± 13.01 lbs. | |

Résumé

L'EFFET D'UNE ALIMENTATION ABONDANTE ET D'UNE ALIMENTATION LIMITÉE SUR LA QUANTITÉ DE PROTÉINE NÉCESSAIRE DANS LA RATION DES PORCS. E. W. Crampton, Collège Macdonald, P.Q.

Ce bulletin couvre une étude des effets d'une alimentation abondante et limitée sur le niveau de protéine nécessaire dans la ration des porcs, indiqué par la rapidité de croissance du porc, l'efficacité de l'utilisation de la nourriture et le classement pour le marché des animaux en vie et habillés. Les résultats indiquent que les rations pour les porcs sevrés ne doivent pas contenir plus de 17% de protéine brute et que ce niveau peut être abaissé à 14% après les premiers 30 jours d'alimentation. Lorsque la proportion de protéine dans la ration des porcs sevrés descend jusqu'à 14% la quantité de grains par unité de nourriture consommée subit une forte diminution. La quantité de nourriture n'a exercé aucune modification sur les effets des différents niveaux de protéine dans la ration. Cependant, quel que soit le niveau de protéine, l'alimentation abondante a provoqué une augmentation de poids de quelque 60% plus rapide. La quantité de nourriture n'a exercé aucun effet sur la longueur du corps, pas plus que sur le classement pour le marché des animaux en vie ou habillés.

APPENDIX

APPENDIX TABLE 1.—WEIGHTS, GAINS, AND FEED CONSUMPTION OF PIGS. LOT 1

| | Pig No. | Weanling period | | | Growing period | | Finishing period | | Total 104 days | |
|----------|---------|-----------------|------|------|----------------|------|------------------|------|----------------|-------|
| | | Initial weight | Gain | Feed | Gain | Feed | Gain | Feed | Gain | Feed |
| Full-fed | 75 | 23 | 30 | 76 | 42 | 120 | 55 | 183 | 158 | 485 |
| | 151 | 49 | 20 | 83 | — | — | — | — | — | — |
| | 120 | 42 | 38 | 100 | 59 | 213 | 62 | 268 | 182 | 721 |
| | 107 | 32 | 34 | 90 | 48 | 159 | 74 | 248 | 186 | 634 |
| | Mean | 36.5 | 30.5 | 87.3 | 49.7 | 164 | 63.7 | 233 | 175.3 | 613.3 |
| Half fed | 92 | 22 | 22 | 46 | 38 | 80 | 47 | 122 | 114 | 308 |
| | 146 | 47 | 18 | 55 | 33 | 89 | — | — | — | — |
| | 142 | 42 | 19 | 56 | 30 | 96 | 31 | 119 | 94 | 341 |
| | 112 | 32 | 24 | 57 | 35 | 92 | 39 | 122 | 110 | 328 |
| | Mean | 35.8 | 20.7 | 53.5 | 32.8 | 89.3 | 39 | 121 | 106 | 325.7 |

APPENDIX TABLE 2.—WEIGHTS, GAINS, AND FEED CONSUMPTION OF PIGS. LOT II

| | Pig No. | Weanling period | | | Growing period | | Finishing period | | Total 104 days | |
|----------|---------|-----------------|------|------|----------------|-------|------------------|-------|----------------|-------|
| | | Initial weight | Gain | Feed | Gain | Feed | Gain | Feed | Gain | Feed |
| Full-fed | 89 | 25 | 35 | 79 | 48 | 156 | 66 | 206 | 191 | 568 |
| | 74 | 27 | 30 | 73 | 46 | 151 | 62 | 203 | 169 | 552 |
| | 113 | 27 | 34 | 95 | 46 | 175 | 63 | 254 | 166 | 657 |
| | 95 | 31 | 40 | 90 | 46 | 167 | 60 | 237 | 167 | 611 |
| | Mean | 27.5 | 34.8 | 84.3 | 46.5 | 161.5 | 62.8 | 224.8 | 173.3 | 597.0 |
| Half-fed | 91 | 25 | 20 | 54 | 24 | 81 | 38 | 118 | 107 | 316 |
| | 71 | 27 | 19 | 51 | 26 | 82 | 35 | 115 | 106 | 312 |
| | 97 | 27 | 23 | 56 | 32 | 98 | 45 | 135 | 113 | 347 |
| | 108 | 31 | 24 | 57 | 37 | 105 | 47 | 130 | 118 | 344 |
| | Mean | 27.5 | 21.5 | 54.5 | 29.8 | 91.3 | 41.2 | 124.5 | 111.0 | 329.8 |

APPENDIX TABLE 3.—WEIGHTS, GAINS, AND FEED CONSUMPTION OF PIGS. LOT III

| | Pig No. | Weanling period | | | Growing period | | Finishing period | | Total 104 days | |
|----------|---------|-----------------|------|------|----------------|-------|------------------|-------|----------------|-------|
| | | Initial weight | Gain | Feed | Gain | Feed | Gain | Feed | Gain | Feed |
| Full-fed | 93 | 27 | 23 | 84 | 49 | 143 | 60 | 212 | 172 | 564 |
| | 79 | 30 | 28 | 83 | 54 | 150 | 72 | 217 | 185 | 566 |
| | 98 | 30 | 40 | 100 | 63 | 200 | 67 | 237 | 198 | 684 |
| | 129 | 38 | 36 | 100 | 57 | 201 | 49 | 242 | 160 | 674 |
| | Mean | 31.3 | 31.8 | 91.8 | 55.8 | 173.5 | 62.0 | 227.0 | 178.8 | 622.0 |
| Half-fed | 86 | 23 | 21 | 53 | 36 | 83 | 35 | 114 | 112 | 312 |
| | 72 | 29 | 21 | 56 | 36 | 83 | 41 | 119 | 132 | 324 |
| | 102 | 28 | 22 | 55 | 50 | 109 | 40 | 132 | 128 | 351 |
| | 145 | 37 | 20 | 57 | 39 | 100 | 39 | 116 | 111 | 339 |
| | Mean | 29.3 | 21.0 | 55.3 | 40.3 | 93.8 | 38.8 | 120.0 | 120.8 | 331.5 |

APPENDIX TABLE 4.—WEIGHTS, GAINS, AND FEED CONSUMPTION OF PIGS. LOT IV

| | Pig No. | Weanling period | | | Growing period | | Finishing period | | Total 104 days | |
|----------|---------|-----------------|------|------|----------------|-------|------------------|-------|----------------|-------|
| | | Initial weight | Gain | Feed | Gain | Feed | Gain | Feed | Gain | Feed |
| Full-fed | 90 | 25 | 37 | 89 | 55 | 160 | 66 | 240 | 191 | 600 |
| | 73 | 33 | 38 | 92 | 59 | 172 | 70 | 251 | 202 | 647 |
| | 111 | 30 | 40* | 98* | — | — | — | — | — | — |
| | 101 | 31 | 34 | 98 | 55 | 177 | 69 | 228 | 189 | 640 |
| | Mean | 29.8 | 37.3 | 94.3 | 56.3 | 169.7 | 68.3 | 239.3 | 194.0 | 629.0 |
| Half-fed | 81 | 26 | 22 | 54 | 37 | 77 | 38 | 111 | 120 | 304 |
| | 85 | 30 | 10 | 50 | 20 | 63 | 39 | 123 | 95 | 311 |
| | 115 | 30 | 16* | 54 | — | — | — | — | — | — |
| | 106 | 30 | 25 | 57 | 38 | 103 | 47 | 129 | 126 | 350 |
| | Mean | 29.0 | 18.3 | 53.8 | 31.7 | 80.3 | 41.3 | 120.7 | 113.7 | 321.7 |

*Estimated values.

APPENDIX TABLE 5.—WEIGHTS, GAINS, AND FEED CONSUMPTION OF PIGS. LOT V.

| | Pig No. | Weanling period | | | Growing period | | Finishing period | | Total 104 days | |
|----------|---------|-----------------|------|------|----------------|-------|------------------|-------|----------------|-------|
| | | Initial weight | Gain | Feed | Gain | Feed | Gain | Feed | Gain | Feed |
| Full-fed | 87 | 19 | 18 | 56 | 23 | 74 | 44 | 126 | 111 | 329 |
| | 70 | 35 | 32 | 100 | 57 | 182 | 76 | 237 | 203 | 654 |
| | 109 | 27 | 19 | 71 | 45 | 138 | 63 | 202 | 161 | 542 |
| | 104 | 33 | 31 | 121 | 52 | 194 | 60 | 228 | 167 | 663 |
| | Mean | 28.5 | 25.0 | 88.0 | 44.3 | 147.0 | 60.8 | 198.3 | 160.5 | 547.0 |
| Half-fed | 88 | 19 | 15 | 47 | 18 | 54 | 22 | 64 | 71 | 209 |
| | 76 | 41 | 14 | 57 | 35 | 86 | 44 | 130 | 114 | 337 |
| | 83 | 26 | 7 | 45 | 18 | 70 | 39 | 110 | 83 | 286 |
| | 100 | 34 | 14 | 48 | 39 | 99 | 48 | 130 | 117 | 335 |
| | Mean | 30.0 | 12.5 | 49.3 | 27.5 | 77.0 | 38.3 | 108.5 | 96.3 | 291.8 |

DIGESTIBILITY STUDIES WITH RUMINANTS. 1. PLANE OF NUTRITION AND DIGESTIBILITY OF HAY

C. J. WATSON,¹ G. W. MUIR,² AND W. M. DAVIDSON³

Central Experimental Farm, Ottawa

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INTRODUCTION

The possible existence of factors affecting the determination of coefficients of digestibility of feeding stuffs has long been recognized. Such factors may include: (*a*) the plane of nutrition; (*b*) the associative effects of feeds; (*c*) the age of the animals; and (*d*) the species. Very little has been accomplished, however, towards definitely assessing the importance and magnitude of these factors.

Accordingly, a study has been commenced on the significance of the coefficients of digestibility of feeding stuffs when determined under certain specific conditions. Attention will be given primarily to the effect of the plane of nutrition and of the association of feeds. The present paper deals with the relation of the level of feeding to the digestibility of a mixed clover and grass hay.

LITERATURE

Data furnishing information concerning the effect of the plane of nutrition upon the digestibility of a roughage for ruminants are found in the published works of the following investigators: Armsby and Fries (1, 2, 3, 4, 5, 6), Armsby, Fries and Braman (7), Forbes, Fries and Braman (8), Henneberg (9), Henneberg and Stohmann (10), Honcamp and Gschwindner (11), Honcamp and Koch (12), Wolff, Funke and Kreuzhage (14), Wolff, Funke, Kreuzhage and Kellner (15).

The data taken from the reports of Armsby and his co-workers and Forbes and his co-workers were incidental to their investigations on energy metabolism. Usually one and sometimes two animals only were used at two or three levels of nutrition. Definite conclusions cannot, therefore, be drawn from their work except to say that, at the most, a change in the level of feeding produced relatively small changes in the digestibility of a roughage.

Similarly, the other investigations cited were characterized, as a general rule, by a lack of sufficient data from which satisfactory conclusions could be drawn. For example, in the works of Henneberg, and Henneberg and Stohmann, the hays were fed at the two levels of approximately 20 and 25 pounds per 1,000 pounds live weight. These quantities represented close to the upper limit of the capacity of the animals and ignored all other levels. In the investigations of Wolff, Funke and Kreuzhage, the different levels of feed were given to three different breeds of sheep of widely varying live weights. Per unit weight of animals the rations were all approximately the same.

¹ Chemist.

² Dominion Animal Husbandman.

³ Assistant in Chemistry.

Honcamp and his collaborators conducted an extensive investigation on the effect of the plane of nutrition upon the digestibility for both roughages and productive rations. The experiments with roughages were conducted in duplicate using sheep as experimental animals. In the later publication cited above, the digestibility showed a slight decrease at the higher levels of feeding. It was not possible, however, to estimate the significance of this. The authors, as a matter of fact, concluded that, except in the case of the crude fibre, the changes were not significant.

Generally, the results of these various investigations would seem to indicate that the plane of nutrition had no very marked effect upon the digestibility of dried roughages. In view of the uncertainties in regard to the conclusions, a further investigation of this question was deemed advisable.

EXPERIMENTAL

Digestion trials were conducted on a mixed clover and grass hay with four grade Shorthorn steers. At the beginning of the experiment, in November, 1933, the animals were a little over two and one-half years old and averaged 985 pounds in weight. The experiment was concluded in April, 1934.

The experiment was divided into five periods, each of which consisted of a preliminary period of 13 days followed by a collection period of 12 days. The collection period was divided into 3 equal subperiods during each of which the feed and excrement were composited and analyzed. In addition, during the last 4 days of the preliminary period, a composite sample was taken of the hay for analysis. The schedule of feeding is given in Table 1.

TABLE 1.—WEIGHTS OF HAY FED TO ANIMALS IN KILOGRAMMES PER ANIMAL PER DAY

| Period | Dates | Kilogrammes of hay per day | | | |
|--------|----------------------|----------------------------|------------------|------------------|----------------|
| | | Animal 20023K | Animal P24396 | Animal P24402 | Animal 276L |
| 1 | 20.11.33 to 19.12.33 | 4.5 | 6.0 | 7.5 | 9.0 |
| 2 | 19.12.33 to 16. 1.34 | 6.0 | 4.5 | 9.0 | 7.5 |
| 3 | 16. 1.34 to 13. 2.34 | 9.0 | 7.5 | 6.0 | 4.5 |
| 4 | 13. 2.34 to 13. 3.34 | 7.5 | 9.0 | 4.5 | 6.0 |
| 5 | 13. 3.34 to 10. 4.34 | 2.5 | 2.5 | 2.5 | 2.5 |

It will be observed that the hay was fed at levels of 2.5, 4.5, 6.0, 7.5 and 9.0 kilogrammes per animal per day. The level of 9.0 kilogrammes represented the limit of the capacity of the animals. In fact, in the cases of animals P24402 and P24396 at this level, hay was refused to the amounts of 3.625 and 8.053 kilogrammes, respectively, for the 12-day period.

The accuracy of coefficients of digestibility determined under the conditions where there are feed refusals is governed by the following factors: (a) percentage of feed refused; (b) regularity of feed refusals;

and (c) similarity of the compositions of the feed refused and the feed offered. In this connection, for this experiment, the refusals amounted to 3.4% and 7.46%, respectively. As far as the comparative compositions of the refused and offered hay were concerned, chemical analyses are given in Table 2 for the feeding stuffs involved.

TABLE 2.—CHEMICAL COMPOSITIONS ON DRY MATTER BASIS OF HAYS OFFERED AND REFUSED AT THE 9.0 LEVEL

| Nutrient | Animal P24402 | | | Animal P24396 | |
|----------------|---------------|-------------|-------|---------------|-------------|
| | Hay offered | Hay refused | | Hay offered | Hay refused |
| | | (1) | (2) | | |
| Organic matter | 92.53 | 92.68 | 92.21 | 92.53 | 92.76 |
| Crude protein | 10.47 | 9.17 | 10.55 | 9.96 | 8.52 |
| Ether extract | 2.21 | 3.27 | 2.36 | 2.29 | 2.32 |
| Crude fibre | 35.83 | 36.42 | 36.16 | 37.11 | 38.47 |
| N-free extract | 44.07 | 43.81 | 43.13 | 43.18 | 43.36 |

It will be seen from Table 2, that the compositions of the hays refused resembled those of the hays offered. The crude protein, however, for sample No. 1 in the case of animal P24402 and for animal P24396 was slightly low. Both from these analyses and from actual observation it was felt that the refusals were due to the limit of the capacity of the animals and not due to discrimination against woody portions of the feed.

The refusals were reasonably regular throughout the trial. As an arbitrary method of computing them in relation to the excretion of the feces, the amount was calculated from 3 days preceding the beginning to 3 days preceding the end of the collection period. The refusals, however, commenced shortly after the start of the preliminary period and continued to the completion of the weighing of the animals, namely, until the third day after the completion of the collection period.

In view of the above considerations, therefore, it was felt that the coefficients of digestibility determined for these two animals at the level of 9.0 kilogrammes were reliable. A check on this assumption would, of course, be furnished by the data obtained on the other two animals where the hay was completely consumed.

In regard to the orientation of the digestion trials, as will be seen from Table 1, the levels of from 4.5 kilogrammes to 9.0 were so arranged that in any one period each animal received a different level. This eliminated any possible effect of a seasonal variation throughout the winter. The level of 2.5 kilogrammes was, however, undertaken simultaneously for all the animals. This quantity of feed represented a condition of semi-starvation. Since no information was at hand concerning the effects of starvation upon an immediate subsequent determination of coefficients of digestibility it was not felt advisable to include this level with the others. For that reason, the results obtained therefrom may, theoretically, lack something of the definiteness of those obtained from the other four levels. From the data obtained in the first four trials, however, information could

be obtained as to whether or not the digestibility was constant throughout the course of the different trials.

For the purpose of the experiment, ten tons of hay were cut with a corn cutter and blown into the barn loft. A sufficient quantity for each trial was selected, mixed thoroughly and stored in the experimental feed bins. Each period was treated as a separate digestion experiment and the analyses of the hay for any one period were related to the calculation of the coefficients of digestibility for that period only.

Iodized salt was furnished at the rate of 28 grammes per animal per day for the first four periods. In the fifth period, representing the level of 2.5 kilogrammes, it was placed before the animals as pressed blocks. In this latter case, the consumption for animals 20023K and P 24396 remained substantially the same. Animals P24402 and 276L, however, consumed two and three times, respectively, as much as in each of the preceding periods.

The daily ration was given in two equal quantities, the first at 5.30 in the morning and the second at 4.30 in the afternoon. Water was offered one hour after each feeding.

RESULTS

The compositions of the feeds and the data used in calculating the coefficients of digestibility are presented in Tables 7 and 8 in the appendix. Summaries of the results are given in Tables 3, 4, 5, and 6.

In Table 3, the coefficients of digestibility are arranged by periods and by levels of feeding. From this table it will be observed that the plane of nutrition was without effect upon the digestibility. The only statistically significant difference noted was in the case of the coefficients of digestibility of the nitrogen-free extract at the levels of 7.5 and 9.0, respectively. The value at the former level was 61.1 and at the latter, 60.2. The odds that this difference of 0.9 was significant are about 25 : 1.

In regard to the differences between periods, the total digestibility as represented by the values for dry matter and organic matter did not change. Some differences were noted, however, for the individual nutrients. In the case of the nitrogen, the values obtained in period 3 were slightly higher than those obtained in periods 1 and 4. The ether extract values in period 2 were slightly higher than those in period 4. For the crude fibre, the coefficients in period 1 were slightly higher than those in period 3. The reverse of this was true for the nitrogen-free extract.

In Table 4, the data are arranged to bring out any individual differences among the animals. Using the coefficients of digestibility of dry matter and organic matter as criteria, it will be observed that no individual differences were found between animals P24396, P24402 and 276L. The coefficients, however, determined with animal 20023K were between one and two absolute per cent below those determined with the other three animals. This difference was small but significant. In regard to the individual nutrients, it was only in the case of the crude fibre values that a significant difference was found between animal 20023K and the other three animals. It would seem, therefore, that while close agreement may be expected between the coefficients of digestibility determined with different, apparently normal, individuals, some slight variations may at

TABLE 3.—COEFFICIENTS OF DIGESTIBILITY FOR PERIODS 1, 2, 3 AND 4, ARRANGED BY PERIODS AND PLANES OF NUTRITION

| Plane of nutrition—(kilos) | 4.5 | 6.0 | 7.5 | 9.0 | Mean | Coefficient of variation | Standard error of mean |
|----------------------------|-------|-------|-------|-------|------|--------------------------|------------------------|
| <i>Dry Matter</i> | | | | | | | |
| Period 1 | 54.0 | 57.0 | 56.9 | 55.6 | 55.9 | 2.51 | ==0.70 |
| Period 2 | 56.5 | 54.7 | 55.7 | 54.4 | 55.3 | 1.74 | ==0.48 |
| Period 3 | 56.2 | 56.6 | 54.7 | 54.7 | 56.0 | 1.58 | ==0.44 |
| Period 4 | 56.2 | 56.4 | 54.9 | 55.9 | 55.9 | 1.20 | ==0.33 |
| Mean | 55.7 | 56.2 | 56.0 | 55.2 | | | |
| Coefficient of variation | 2.08 | 1.81 | 1.58 | 1.30 | | | |
| Standard error of mean | ±0.58 | ±0.51 | ±0.44 | ±0.36 | | | |
| <i>Organic Matter</i> | | | | | | | |
| Period 1 | 55.0 | 57.8 | 57.8 | 56.6 | 56.8 | 2.34 | ±0.66 |
| Period 2 | 57.7 | 55.9 | 56.9 | 55.4 | 56.5 | 1.82 | ±0.52 |
| Period 3 | 57.1 | 57.7 | 57.4 | 55.4 | 56.9 | 1.81 | ±0.52 |
| Period 4 | 57.2 | 57.1 | 55.7 | 56.6 | 56.7 | 1.21 | ±0.34 |
| Mean | 56.8 | 57.1 | 57.0 | 56.0 | | | |
| Coefficient of variation | 2.11 | 1.53 | 1.60 | 1.24 | | | |
| Standard error of mean | ±0.60 | ±0.44 | ±0.46 | ±0.35 | | | |
| <i>Nitrogen</i> | | | | | | | |
| Period 1 | 53.1 | 56.0 | 52.5 | 52.4 | 53.5 | 3.17 | ±0.85 |
| Period 2 | 57.6 | 55.8 | 56.2 | 53.3 | 55.7 | 3.22 | ±0.90 |
| Period 3 | 58.7 | 56.8 | 58.6 | 57.2 | 57.8 | 1.68 | ±0.48 |
| Period 4 | 53.1 | 55.6 | 51.9 | 54.9 | 53.9 | 3.13 | ±0.84 |
| Mean | 55.6 | 56.1 | 54.8 | 54.5 | | | |
| Coefficient of variation | 5.31 | 0.94 | 5.78 | 3.86 | | | |
| Standard error of mean | ±1.47 | ±0.26 | ±1.58 | ±1.05 | | | |
| <i>Ether Extract</i> | | | | | | | |
| Period 1 | 37.4 | 41.0 | 41.3 | 39.6 | 39.8 | 4.47 | ±0.89 |
| Period 2 | 39.8 | 42.2 | 40.6 | 39.8 | 40.6 | 2.79 | ±0.57 |
| Period 3 | 39.3 | 42.6 | 40.1 | 40.9 | 40.7 | 3.47 | ±0.71 |
| Period 4 | 40.0 | 38.9 | 35.9 | 36.1 | 37.7 | 5.42 | ±1.02 |
| Mean | 39.1 | 41.2 | 39.5 | 39.1 | | | |
| Coefficient of variation | 3.04 | 4.03 | 6.16 | 5.32 | | | |
| Standard error of mean | ±0.59 | ±0.83 | ±1.22 | ±1.04 | | | |
| <i>Crude Fibre</i> | | | | | | | |
| Period 1 | 52.3 | 56.2 | 56.6 | 54.7 | 55.0 | 3.54 | ==0.97 |
| Period 2 | 53.9 | 51.4 | 52.9 | 50.6 | 52.2 | 2.84 | ==0.74 |
| Period 3 | 52.5 | 52.4 | 52.2 | 49.6 | 51.7 | 2.69 | ==0.70 |
| Period 4 | 53.3 | 53.7 | 51.3 | 53.7 | 53.0 | 2.17 | ==0.58 |
| Mean | 53.0 | 53.4 | 53.3 | 52.2 | | | |
| Coefficient of variation | 1.40 | 3.89 | 4.37 | 4.67 | | | |
| Standard error of mean | ±0.37 | ±1.04 | ±1.16 | ±1.22 | | | |
| <i>N-Free Extract</i> | | | | | | | |
| Period 1 | 58.4 | 60.3 | 60.5 | 59.7 | 59.7 | 1.59 | ==0.47 |
| Period 2 | 61.3 | 60.2 | 61.0 | 60.4 | 60.7 | 0.85 | ==0.26 |
| Period 3 | 60.9 | 62.7 | 61.9 | 60.3 | 61.5 | 1.73 | ==0.53 |
| Period 4 | 61.9 | 61.3 | 60.9 | 60.4 | 61.1 | 1.04 | ==0.32 |
| Mean | 60.6 | 61.1 | 61.1 | 60.2 | | | |
| Coefficient of variation | 2.54 | 1.90 | 0.97 | 0.56 | | | |
| Standard error of mean | ±0.77 | ±0.58 | ±0.30 | ±0.17 | | | |

TABLE 4.—COEFFICIENTS OF DIGESTIBILITY FOR PERIODS 1 TO 4, ARRANGED BY ANIMALS

| | Animal 20023K | Animal P24396 | Animal P24402 | Animal 276L |
|--------------------------|------------------|------------------|------------------|----------------|
| <i>Dry Matter</i> | | | | |
| 4.5 kilos | 54.0 | 56.5 | 56.2 | 56.2 |
| 6.0 kilos | 54.7 | 57.0 | 56.6 | 56.4 |
| 7.5 kilos | 54.9 | 56.5 | 56.9 | 55.7 |
| 9.0 kilos | 54.7 | 55.9 | 54.4 | 55.6 |
| Mean | 54.6 | 56.5 | 56.0 | 56.0 |
| Coefficient of variation | 0.73 | 0.80 | 2.00 | 0.69 |
| Standard error of mean | ±0.20 | ±0.23 | ±0.56 | ±0.19 |
| <i>Organic Matter</i> | | | | |
| 4.5 kilos | 55.0 | 57.7 | 57.2 | 57.1 |
| 6.0 kilos | 55.9 | 57.8 | 57.7 | 57.1 |
| 7.5 kilos | 55.7 | 57.4 | 57.8 | 56.9 |
| 9.0 kilos | 55.4 | 56.6 | 55.4 | 56.6 |
| Mean | 55.5 | 57.4 | 57.0 | 56.9 |
| Coefficient of variation | 0.71 | 0.95 | 1.96 | 0.42 |
| Standard error of mean | ±0.20 | ±0.27 | ±0.56 | ±0.12 |
| <i>Nitrogen</i> | | | | |
| 4.5 kilos | 53.1 | 57.6 | 53.1 | 58.7 |
| 6.0 kilos | 55.8 | 56.0 | 56.8 | 55.6 |
| 7.5 kilos | 51.9 | 58.6 | 52.5 | 56.2 |
| 9.0 kilos | 57.2 | 54.9 | 53.3 | 52.4 |
| Mean | 54.5 | 56.8 | 53.9 | 55.7 |
| Coefficient of variation | 4.46 | 2.90 | 3.61 | 4.65 |
| Standard error of mean | ±1.22 | ±0.82 | ±0.97 | ±1.30 |
| <i>Ether Extract</i> | | | | |
| 4.5 kilos | 37.4 | 39.8 | 40.0 | 39.3 |
| 6.0 kilos | 42.2 | 41.0 | 42.6 | 38.9 |
| 7.5 kilos | 35.9 | 40.1 | 41.3 | 40.6 |
| 9.0 kilos | 40.9 | 36.1 | 39.8 | 39.6 |
| Mean | 39.1 | 39.3 | 40.9 | 39.6 |
| Coefficient of variation | 7.52 | 5.50 | 3.18 | 1.83 |
| Standard error of mean | ±1.47 | ±1.08 | ±0.65 | ±0.36 |
| <i>Crude Fibre</i> | | | | |
| 4.5 kilos | 52.3 | 53.9 | 53.3 | 52.5 |
| 6.0 kilos | 51.4 | 56.2 | 52.4 | 53.7 |
| 7.5 kilos | 51.3 | 52.2 | 56.6 | 52.9 |
| 9.0 kilos | 49.6 | 53.7 | 50.6 | 54.7 |
| Mean | 51.2 | 54.0 | 53.2 | 53.5 |
| Coefficient of variation | 2.20 | 3.06 | 4.73 | 1.82 |
| Standard error of mean | ±0.56 | ±0.83 | ±1.26 | ±0.49 |
| <i>N-Free Extract</i> | | | | |
| 4.5 kilos | 58.4 | 61.3 | 61.9 | 60.9 |
| 6.0 kilos | 60.2 | 60.3 | 62.7 | 61.3 |
| 7.5 kilos | 60.9 | 61.9 | 60.5 | 61.0 |
| 9.0 kilos | 60.3 | 60.4 | 60.4 | 59.7 |
| Mean | 60.0 | 61.0 | 61.4 | 60.7 |
| Coefficient of variation | 1.80 | 1.25 | 1.82 | 1.16 |
| Standard error of mean | ±0.54 | ±0.38 | ±0.56 | ±0.35 |

times occur. These variations would appear, from the data reported above, to be reflected in variations in the fermentation of the crude fibre. This is in accord with previous statements by the authors (13) concerning the important role played by the action of fermentation in modifying the apparent digestibility of feeds by ruminants.

TABLE 5.—AVERAGES OF COEFFICIENTS OF DIGESTIBILITY OBTAINED IN PERIODS 1 TO 4.

| Nutrient | Mean (16 samples) | Range of individual values | Coefficient of variation | Standard error of mean |
|----------------|----------------------|----------------------------------|--------------------------------|------------------------------|
| Dry matter | 55.8 | 54.0-57.0 | 1.70 | ±0.24 |
| Organic matter | 56.7 | 55.0-57.8 | 1.67 | ±0.24 |
| Nitrogen | 55.2 | 51.9-58.7 | 4.10 | ±0.57 |
| Ether extract | 39.7 | 35.9-42.6 | 4.82 | ±0.48 |
| Crude fibre | 53.0 | 49.6-56.6 | 3.53 | ±0.47 |
| N-free extract | 60.8 | 58.4-62.7 | 1.64 | ±0.25 |

Table 5 presents a summary of the sixteen coefficients of digestibility obtained for each nutrient at the levels of 4.5 to 9.0 kilos.

TABLE 6.—COEFFICIENTS OF DIGESTIBILITY FOR PERIOD 5, AT A LEVEL OF 2.5 KILOS PER DAY

| Animal No. | Dry matter | Organic matter | Nitro- gen | Ether extract | Crude fibre | N-free extract |
|--------------------------|---------------|-------------------|---------------|------------------|----------------|-------------------|
| 20023K | 52.5 | 53.2 | 51.6 | 37.8 | 50.7 | 56.4 |
| P24396 | 53.9 | 54.9 | 51.4 | 38.6 | 50.4 | 59.9 |
| P24402 | 52.4 | 53.7 | 49.9 | 39.0 | 49.3 | 58.4 |
| 276L | 55.9 | 57.0 | 54.5 | 38.7 | 55.1 | 60.0 |
| Mean | 53.7 | 54.7 | 51.9 | 38.5 | 51.4 | 58.7 |
| Coefficient of variation | 3.04 | 3.09 | 3.70 | 1.33 | 4.97 | 2.87 |
| Standard error of mean | ±0.82 | ±0.85 | ±0.96 | ±0.26 | ±1.28 | ±0.84 |

In Table 6 is given a summary of the coefficients of digestibility obtained in period 5 at the 2.5 level. The results obtained with animal 276L were similar in degree to those obtained at the other levels. In the case of the other three animals, however, the values were slightly lower, so that the averages of the four animals were slightly lower than those of any other level. The differences between the average values given for the levels of 4.5 to 9.0 in Table 5, and the average values for the level of 2.5 were significant. Considering the individual planes of nutrition, though, the differences between the levels of 2.5, 4.5 and 9.0 were not significant, whereas between the 2.5 level and either the 6.0 or 7.5 levels, the differences were, in general, significant. It may be concluded that at the 2.5 level, the digestibility was possibly slightly lowered.

At this latter level, the animals were on a semi-starvation ration. The food was bolted with extreme rapidity and it is possible that rumination and digestion were neither normal nor complete. Even under these conditions, the coefficients were only slightly lowered.

It may, therefore, be justifiably concluded from all the evidence presented above that the plane of nutrition, per se, did not affect the digestibility of a dried roughage when fed to steers.

SUMMARY AND CONCLUSIONS

1. Four grade shorthorn steers were fed a ration of mixed clover and grass hay at levels of 2.5, 4.5, 6.0, 7.5 and 9.0 kilogrammes per animal per day.

2. For the range of 4.5 to 9.0 kilogrammes per day, the plane of nutrition did not significantly affect the coefficients of digestibility.

3. At the 2.5 level, the average values for the coefficients of digestibility were slightly lower than at the other levels. It was suggested that this might be due to the low state of nutrition to which the animals were reduced rather than to an effect of the plane of nutrition, per se.

4. From the data obtained at the levels of 4.5 to 9.0, it was concluded that the digestibility of the hay remained constant from period to period throughout the trial. In certain cases, however, the individual constituents showed slight variations.

5. From the same data it was found that while the digestibilities of all four animals were similar, the values obtained with one animal were slightly but significantly lower than those obtained with the other three. This difference was between one and two absolute per cent.

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Résumé

ÉTUDE DE DIGESTIBILITÉ SUR LES RUMINANTS. 1. DIGESTIBILITÉ DU FOIN DONNÉ EN DIFFÉRENTES QUANTITÉS. C. J. Watson, G. W. Muir et W. M. Davidson, Ferme expérimentale centrale, Ottawa, Ont.

Quatre bœufs Shorthorn métis recevaient une ration composée d'un mélange de foin de trèfle et de graminées, à raison de 2.5, 4.5, 6.0, 7.5, et 9.0 kilogrammes par tête et par jour. Les coefficients de digestibilité n'ont pas été sensiblement affectés tant que la quantité donnée restait dans les limites de 4.5 à 9 kgs. par jour. Au niveau de 2.5 les valeurs moyennes des coefficients de digestibilité étaient un peu plus faibles qu'aux autres niveaux. On a pensé que ceci pourrait être l'effet du pauvre état de nutrition auquel les animaux étaient réduits plutôt que celui du degré de nutrition par lui-même. Se basant sur les résultats obtenus aux niveaux de 4.5 et 9.0, on a conclu que la digestibilité du foin est restée constante d'une période à l'autre pendant tout l'essai. Dans certains cas cependant les éléments constitutifs présentaient de légères variations. D'après les mêmes données on a constaté que la digestibilité des quatre bœufs était semblable, mais que les valeurs obtenues avec un animal étaient légèrement plus faibles, mais de façon significative, que celles obtenues avec les trois autres. La différence était entre un et deux absolu pour cent.

APPENDIX

TABLE 7.—COMPOSITION OF HAY

| | Period 1 | Period 2 | Period 3 | Period 4 | Period 5 |
|----------------|----------|----------|----------|----------|----------|
| Moisture | 7.15 | 8.02 | 7.24 | 7.23 | 8.20 |
| Ash | 6.82 | 6.86 | 7.11 | 6.93 | 6.99 |
| Crude protein | 9.09 | 9.63 | 10.00 | 9.24 | 9.62 |
| Ether extract | 1.91 | 2.03 | 2.18 | 2.12 | 2.22 |
| Crude fibre | 34.34 | 32.95 | 33.20 | 34.42 | 32.95 |
| N-free extract | 40.69 | 40.51 | 40.27 | 40.06 | 40.02 |

TABLE 8.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY
(Collection period of 12 days. Weights in kilogrammes)

| | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-free extract |
|----------------------|---------------|-------------------|----------|------------------|----------------|-------------------|
| <i>Period 1</i> | | | | | | |
| <i>Animal 20023K</i> | | | | | | |
| In hay | 50.139 | 46.456 | 0.786 | 1.031 | 18.544 | 21.973 |
| In feces | 23.093 | 20.915 | 0.369 | 0.646 | 8.849 | 9.153 |
| Digested | 27.046 | 25.541 | 0.417 | 0.385 | 9.695 | 12.820 |
| Coefficient | 54.0 | 55.0 | 53.1 | 37.4 | 52.3 | 58.4 |
| <i>Animal P24396</i> | | | | | | |
| In hay | 66.852 | 61.942 | 1.048 | 1.375 | 24.725 | 29.297 |
| In feces | 28.783 | 26.153 | 0.461 | 0.812 | 10.827 | 11.613 |
| Digested | 38.069 | 35.789 | 0.587 | 0.563 | 13.898 | 17.684 |
| Coefficient | 57.0 | 57.8 | 56.0 | 41.0 | 56.2 | 60.3 |
| <i>Animal P24402</i> | | | | | | |
| In hay | 83.565 | 77.427 | 1.310 | 1.719 | 30.906 | 36.621 |
| In feces | 36.047 | 32.644 | 0.622 | 1.010 | 13.421 | 14.473 |
| Digested | 47.518 | 44.783 | 0.688 | 0.709 | 17.485 | 22.148 |
| Coefficient | 56.9 | 57.8 | 52.5 | 41.3 | 56.6 | 60.5 |
| <i>Animal 276L</i> | | | | | | |
| In hay | 100.278 | 92.912 | 1.571 | 2.063 | 37.087 | 43.945 |
| In feces | 44.490 | 40.355 | 0.748 | 1.246 | 16.807 | 17.694 |
| Digested | 55.788 | 52.557 | 0.823 | 0.817 | 20.280 | 26.251 |
| Coefficient | 55.6 | 56.6 | 52.4 | 39.6 | 54.7 | 59.7 |
| <i>Period 2</i> | | | | | | |
| <i>Animal 20023K</i> | | | | | | |
| In hay | 66.225 | 61.286 | 1.109 | 1.463 | 23.724 | 29.167 |
| In feces | 29.969 | 27.024 | 0.490 | 0.845 | 11.547 | 11.621 |
| Digested | 36.256 | 34.262 | 0.619 | 0.618 | 12.177 | 17.546 |
| Coefficient | 54.7 | 55.9 | 55.8 | 42.2 | 51.4 | 60.2 |
| <i>Animal P24396</i> | | | | | | |
| In hay | 49.669 | 45.964 | 0.832 | 1.096 | 17.793 | 21.875 |
| In feces | 21.619 | 19.456 | 0.353 | 0.660 | 8.203 | 8.454 |
| Digested | 28.050 | 26.508 | 0.479 | 0.436 | 9.590 | 13.421 |
| Coefficient | 56.5 | 57.7 | 57.6 | 39.8 | 53.9 | 61.3 |
| <i>Animal P24402</i> | | | | | | |
| In hay | 96.127 | 88.956 | 1.615 | 2.092 | 34.418 | 42.348 |
| In feces | 43.860 | 39.675 | 0.755 | 1.260 | 16.986 | 16.791 |
| Digested | 52.267 | 49.281 | 0.860 | 0.832 | 17.432 | 25.557 |
| Coefficient | 54.4 | 55.4 | 53.3 | 39.8 | 50.6 | 60.4 |
| <i>Animal 276L</i> | | | | | | |
| In hay | 82.782 | 76.608 | 1.386 | 1.827 | 29.655 | 36.459 |
| In feces | 36.666 | 32.988 | 0.607 | 1.086 | 13.965 | 14.236 |
| Digested | 46.116 | 43.620 | 0.779 | 0.741 | 15.690 | 22.223 |
| Coefficient | 55.7 | 56.9 | 56.2 | 40.6 | 52.9 | 61.0 |

TABLE 8.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY—*Continued*
(Collection period of 12 days. Weights in kilogrammes)

| | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-free extract |
|----------------------|---------------|-------------------|----------|------------------|----------------|-------------------|
| <i>Period 3</i> | | | | | | |
| <i>Animal 20023K</i> | | | | | | |
| In hay | 100.181 | 92.502 | 1.728 | 2.354 | 35.856 | 43.493 |
| In feces | 45.410 | 41.258 | 0.740 | 1.392 | 18.078 | 17.259 |
| Digested | 54.771 | 51.244 | 0.988 | 0.962 | 17.778 | 26.234 |
| Coefficient | 54.7 | 55.4 | 57.2 | 40.9 | 49.6 | 60.3 |
| <i>Animal P24396</i> | | | | | | |
| In hay | 83.484 | 77.085 | 1.440 | 1.962 | 29.880 | 36.243 |
| In feces | 36.335 | 32.878 | 0.596 | 1.176 | 14.295 | 13.793 |
| Digested | 47.149 | 44.207 | 0.844 | 0.786 | 15.585 | 22.450 |
| Coefficient | 56.5 | 57.4 | 58.6 | 40.1 | 52.2 | 61.9 |
| <i>Animal P24402</i> | | | | | | |
| In hay | 66.787 | 61.668 | 1.152 | 1.570 | 23.904 | 28.994 |
| In feces | 28.953 | 26.065 | 0.498 | 0.902 | 11.373 | 10.802 |
| Digested | 37.834 | 35.603 | 0.654 | 0.668 | 12.531 | 18.192 |
| Coefficient | 56.6 | 57.7 | 56.8 | 42.6 | 52.4 | 62.7 |
| <i>Animal 276L</i> | | | | | | |
| In hay | 50.091 | 46.251 | 0.864 | 1.177 | 17.928 | 21.746 |
| In feces | 21.960 | 19.863 | 0.357 | 0.714 | 8.514 | 8.495 |
| Digested | 28.131 | 26.383 | 0.507 | 0.463 | 9.414 | 13.251 |
| Coefficient | 56.2 | 57.1 | 58.7 | 39.3 | 52.5 | 60.9 |
| <i>Period 4</i> | | | | | | |
| <i>Animal 20023K</i> | | | | | | |
| In hay | 83.493 | 77.256 | 1.331 | 1.908 | 30.978 | 36.054 |
| In feces | 37.676 | 34.232 | 0.640 | 1.224 | 15.088 | 14.085 |
| Digested | 45.817 | 43.024 | 0.691 | 0.684 | 15.890 | 21.969 |
| Coefficient | 54.9 | 55.7 | 51.9 | 35.9 | 51.3 | 60.9 |
| <i>Animal P24396</i> | | | | | | |
| In hay | 92.682 | 85.741 | 1.494 | 2.116 | 34.279 | 40.009 |
| In feces | 40.882 | 37.219 | 0.673 | 1.353 | 15.871 | 15.851 |
| Digested | 51.800 | 48.522 | 0.821 | 0.763 | 18.408 | 24.158 |
| Coefficient | 55.9 | 56.6 | 54.9 | 36.1 | 53.7 | 60.4 |
| <i>Animal P24402</i> | | | | | | |
| In hay | 50.096 | 46.354 | 0.799 | 1.145 | 18.587 | 21.632 |
| In feces | 21.952 | 19.826 | 0.375 | 0.687 | 8.679 | 8.229 |
| Digested | 28.144 | 26.528 | 0.424 | 0.458 | 9.908 | 13.403 |
| Coefficient | 56.2 | 57.2 | 53.1 | 40.0 | 53.3 | 61.9 |
| <i>Animal 276L</i> | | | | | | |
| In hay | 66.794 | 61.805 | 1.065 | 1.526 | 24.782 | 28.843 |
| In feces | 29.133 | 26.487 | 0.473 | 0.932 | 11.473 | 11.177 |
| Digested | 37.661 | 35.318 | 0.592 | 0.594 | 13.309 | 17.666 |
| Coefficient | 56.4 | 57.1 | 55.6 | 38.9 | 53.7 | 61.3 |

TABLE 8.—CALCULATION OF COEFFICIENTS OF DIGESTIBILITY—*Concluded*
(Collection period of 12 days. Weights in kilogrammes)

| | Dry matter | Organic matter | Nitrogen | Ether extract | Crude fibre | N-free extract |
|----------------------|---------------|-------------------|----------|------------------|----------------|-------------------|
| <i>Period 5</i> | | | | | | |
| <i>Animal 20023K</i> | | | | | | |
| In hay | 27.540 | 25.446 | 0.461 | 0.666 | 9.885 | 12.006 |
| In feces | 13.085 | 11.901 | 0.223 | 0.414 | 4.876 | 5.229 |
| Digested | 14.455 | 13.545 | 0.238 | 0.252 | 5.009 | 6.777 |
| Coefficient | 52.5 | 53.2 | 51.6 | 37.8 | 50.7 | 56.4 |
| <i>Animal P24396</i> | | | | | | |
| In hay | 27.540 | 25.446 | 0.461 | 0.666 | 9.885 | 12.006 |
| In feces | 12.709 | 11.488 | 0.224 | 0.409 | 4.905 | 4.811 |
| Digested | 14.831 | 13.958 | 0.237 | 0.257 | 4.980 | 7.195 |
| Coefficient | 53.9 | 54.9 | 51.4 | 38.6 | 50.4 | 59.9 |
| <i>Animal P24402</i> | | | | | | |
| In hay | 27.540 | 25.446 | 0.461 | 0.666 | 9.885 | 12.006 |
| In feces | 13.112 | 11.785 | 0.231 | 0.406 | 5.014 | 4.992 |
| Digested | 14.428 | 13.661 | 0.230 | 0.260 | 4.871 | 7.014 |
| Coefficient | 52.4 | 53.7 | 49.9 | 39.0 | 49.3 | 58.4 |
| <i>Animal 276L</i> | | | | | | |
| In hay | 27.540 | 25.446 | 0.461 | 0.666 | 9.885 | 12.006 |
| In feces | 12.154 | 10.936 | 0.210 | 0.408 | 4.438 | 4.796 |
| Digested | 15.386 | 14.510 | 0.251 | 0.258 | 5.447 | 7.210 |
| Coefficient | 55.9 | 57.0 | 54.5 | 38.7 | 55.1 | 60.0 |

MECHANICAL AIDS TO CROP EXPERIMENTS¹

By H. J. KEMP²

Dominion Experimental Station, Swift Current, Saskatchewan.

INTRODUCTION

Accuracy and economy in conducting crop experiments depend greatly on the use of suitable mechanical equipment. Modern methods of conducting field experiments with various kinds of crops include the use of a large series of small plots of various sizes and usually consisting of one or more rows measuring from $3\frac{1}{2}$ feet to $18\frac{1}{2}$ feet long. Rod-row test plots for cereal varieties became more extensively used in the United States and Canada about ten years ago. With the introduction of this system of cereal plot testing, appeared certain difficulties affecting either the seeding, harvesting or threshing of the crop. Replication of small plots was deemed essential to secure the maximum of accuracy, but the extent of replication or the number of varieties to be tested was controlled by the hand labour available. Work done by hand labour often gave poor results, even though the work was carefully done. The loss of such work was costly. Perhaps more costly is the retarded progress of experimental work dealing with major problems through lack of suitable facilities.

Some experiments require a certain kind of work to be carried out as quickly as possible in order to secure good results. For instance, at seeding time it is desirable that all the varieties in a test be sown in a comparatively short space of time so that all varieties will get as nearly as possible an even start, since weather factors may influence the results. The use of suitable equipment helps considerably to make this more certain.

During recent years rod-row plot methods have been extended to variety and cultural tests of fodder crops. The recent introduction of commercial fertilizers in Western Canada has also promoted considerable experimentation involving the use of this method. Some difficulties in seeding were encountered when attempts were made to conduct fodder crop and fertilizer tests in rod-row plots, which necessitated the construction of seeding machines suitable for these purposes. Still more recently there has been a demand for a suitable mechanical method of planting single kernels of small grains at two-inch intervals in order to obtain even stands and thereby permit comparisons of individual plants.

DEVELOPMENT OF PLOT MACHINERY AT SWIFT CURRENT

Rod-row testing of cereal varieties began at the Dominion Experimental Station at Swift Current in 1924. Hand labour was used for the work. Difficulties were encountered with seeding, harvesting and threshing. In 1925 an effort was made to correct the difficulties by resorting to much more careful hand methods. The results were no better than those of the previous year. Germination was very irregular. The growth was very patchy. Harvesting was made difficult because of sawfly damage,

¹ Read at the meeting of the Western Canadian Society of Agronomy held in connection with the World's Grain Exhibition and Conference, Regina, Sask., July 28, 1933.

² Acting Superintendent.

and a small threshing machine was required to thresh and clean the grain without causing mixing of varieties. Closer observation indicated that rod-row plot testing could be made more successful if suitable mechanical equipment were made available for the work. In 1926 a small rod-row seeder, rod-row cutter and a nursery thresher were designed and constructed. The machines, though far from perfect, greatly improved the cereal work that year. To further improve these machines, a machine shop was equipped at Swift Current with the necessary tools. The machines were re-designed and a number constructed to supply other Experimental Farms of the Dominion Government as well as other institutions.

SEEDING MACHINES

The first rod-row machine to be constructed at Swift Current was a rod-row seeder. Failures to get good stands in 1924 and 1925 were found to be due to the difficulty of getting the seeds planted at an even depth into moist soil below a surface of two or three inches of dry dust. Opening furrows with small hand plows even for a short period of time before planting the seeds seemed to aggravate the trouble. Moist soil became mixed with dry dust and the furrow would soon become dry after exposure to the sun and winds. Frequently the furrows would become blown full with dry dust if they were left exposed too long. As a result much of the seed could not be planted into moist soil by hand, and invariably in covering the seed the loose free running soil would cover the seed before the moist soil could be made to reach it.

In designing the first rod-row seeder an effort was made not only to ensure a uniform stand, but also to facilitate the work of seeding small plots in as many other ways as possible. Steady improvement has been made to these seeders to the present date, and in addition other types have been constructed to meet the needs of special kinds of work. All have been constructed, however, to perform the following work in one operation:

1. Mark and firm the soil for successive drill rows.
2. Open the seed furrows to an even depth.
3. Deposit a previously weighed amount of seed evenly in moist soil in any length of row up to $18\frac{1}{2}$ feet without having seed left over at the end of the row.
4. When seed is not previously weighed and packeted the machine is designed to sow small grains by calibration with a variation of less than 5% from the desired rate.
5. Cover the seed immediately after planting.
6. Pack the soil over the seed.

Several types of seeders have been constructed some of which have been discarded and others are still in the experimental stage. Those which are to be described here are as follows:

1. Rod-row seeder—9-inch circular hopper type.
2. Rod-row seeder—Endless belt type.
3. Continuous row seeder—Calibrated fluted drum type.

Rod-Row Seeder Nine-inch Fluted Ring Type

Purpose

This seeder is designed to deliver a definite quantity of seed in a definite length of row, the quantity being determined by the thousand-kernel weight and the percentage germination, to ensure the same number of viable seeds being sown in each per unit length of row. This requires that the seed placed in the hopper be sown evenly and so distributed that all the seed is sown as nearly as possible in the prescribed length of row.

Description

The seeder consists of a round aluminum hopper, nine inches in diameter, in which rotates a fluted seed ring. On the seed ring covering the flutes is a loading ring, which forms a circular "V" shaped recess with the inner sloping sides of the round hopper. The distance around this "V" shaped recess is about 24 inches. The seed is placed in a portion of this circular recess, depending on the length of the row to be sown. The portion of the hopper which is to receive seed is determined by trial by pushing the machine over ground similar to that which is to be sown. When the seeder is thus calibrated metal markers are attached to the loading ring to indicate the portion which is to receive seed for the length of row to be sown. When this preliminary is completed, the machine is set to sow any number of rows of the desired length unless soil conditions change sufficiently to affect materially the traction of the drive wheels.

After the seed is distributed evenly in the loading ring, the loading

ring is lifted, allowing the seed to fall into the fluted perimeter of the seed ring below. As the machine is pushed over the ground, the seed ring is caused to rotate by means of a 6-inch bevel crown gear on the underside of the hopper meshing with a bevel pinion gear on a $\frac{5}{8}$ -inch drive shaft. This drive shaft forms the axle for two 12-inch drive wheels. The seed ring makes one revolution for every six revolutions of the drive wheels. As the seed ring rotates, it delivers the seed to an opening in the bottom of the hopper from where it is conducted by a tube to a

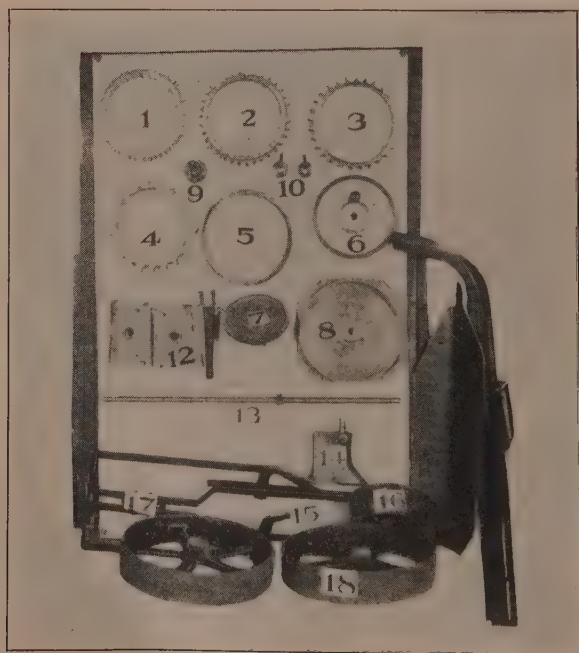


FIGURE 3. Parts of Rod Row Seeder.
Nine-inch fluted ring type

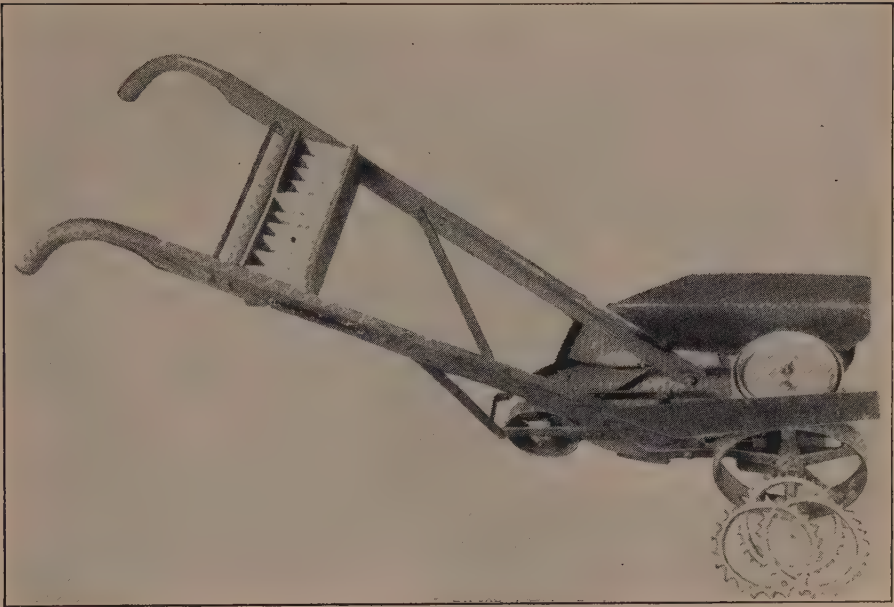


FIGURE 1. Rod Row Seeder. Nine-inch fluted ring type

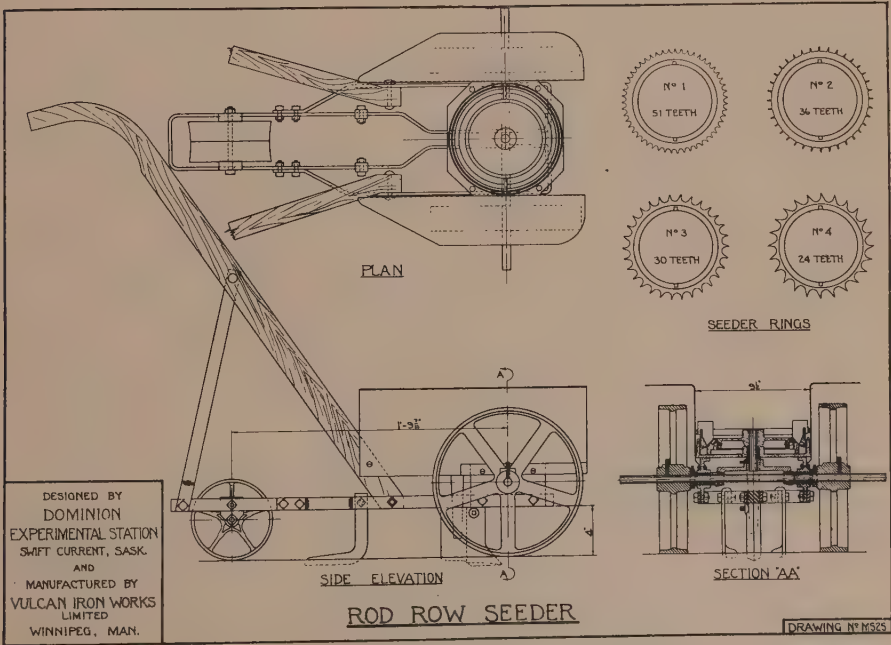


FIGURE 2. Plan of Rod Row Seeder. Nine-inch fluted ring type

furrow opener. The furrow opener is adjustable to sow at various depths to 3 inches deep. The furrow opener is made with sides 4 inches high and extending back 2 inches past the point where seed is delivered to the furrow to keep dry soil from coming into contact with the seed. The seed is thus planted in a fresh moist furrow and immediately covered with soil by the covering irons followed by packing with a 6-inch packing wheel and again packed with one of the drive wheels during the seeding of the next row. The drive wheels are adjustable on the axle shaft so that they can be used as markers and for smoothing and firming the soil previous to planting.

Capacity

The seeder will plant from 300 to 400 single rod rows per 10-hour day depending on soil and weather conditions. The machine is suitable also for sowing many other kinds of seeds besides cereal crops. This machine is now being manufactured by the Vulcan Iron Works, Winnipeg, Manitoba, Canada.

Continuous Single-Row Seeder Adjustable Fluted Drum Type

Purpose

The continuous single-row seeder is designed to sow seed at a controlled rate. The rate is based on pounds or bushels per acre and modified by the percentage germination of the seed. Wheat, oats, barley and various grass seeds are sown in any length of row. It is particularly suitable for sowing plots having long rows or a considerable number of short rows. Provision is also made to empty and clean out the hopper readily to facilitate the work when it is necessary to change the seed often.

Description

A quantity of seed is placed in a square shaped hopper constructed of sheet metal. At the bottom of the hopper the seed comes into contact with a revolving 3-inch fluted cylinder or drum. The fluted cylinder is mounted on a threaded drive shaft which is threaded at one end with 12 threads per inch. At the opposite end of this threaded cylinder shaft is a set of 3 spur gears which provides 3 speeds for the fluted cylinder. The

spur gears obtain their motion from the two 12-inch drive wheels. Twelve gauge slides, each having different size seed openings varying in width by $1/12$ -inch are provided. A gauge slide to suit the size and amount of seed to be sown is chosen and placed in position. The fluted seed cylinder is adjusted by screwing it right or left so that the fluted portion ex-

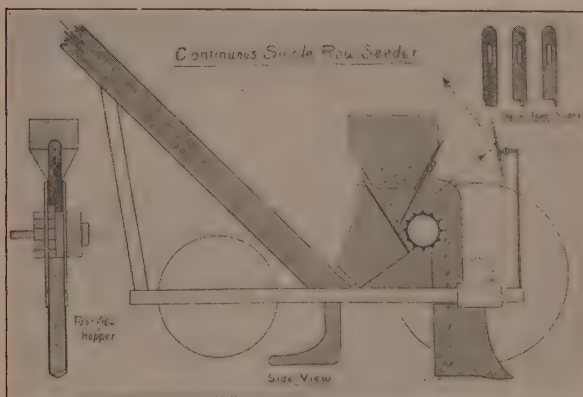


FIGURE 4. Diagram of Continuous Single Row Seeder

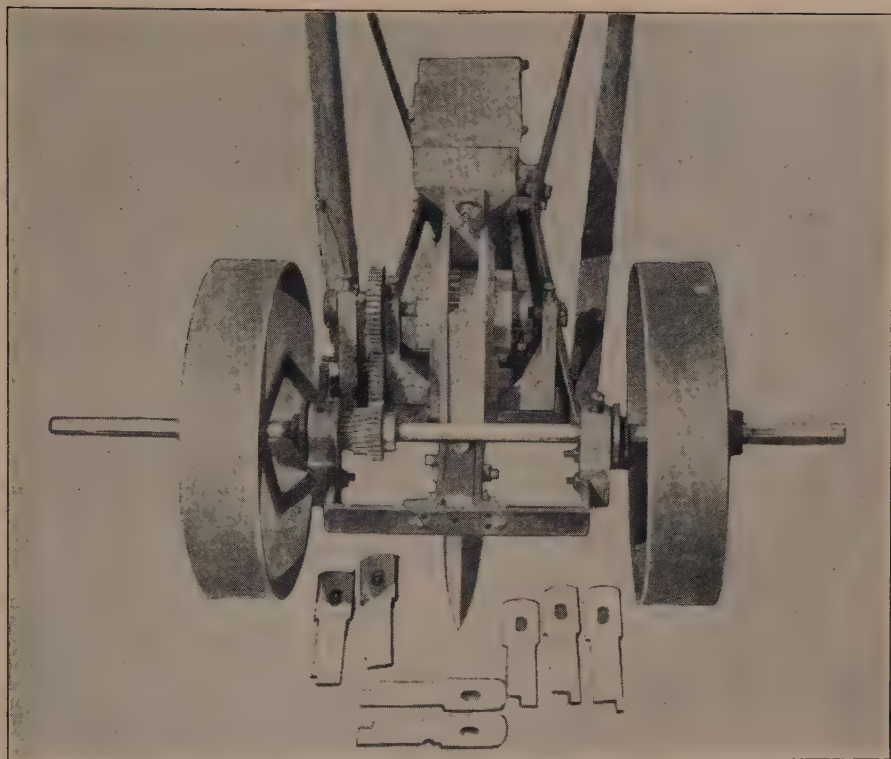


FIGURE 5. Continuous Single Row Seeder. Front view.

posed to the seeds coincides with the width of the opening of the gauge slide. Each complete turn of the fluted cylinder moves it $1/12$ of an inch right or left depending on which way it is turned. Thirty-six adjustments within a seed opening space are made possible by the combination of the 3 seed cylinder speeds and the gauge slides. The seed is carried up and over the top of the seed cylinder by the exposed flutes and dropped into a seed conductor tube which guides it to the furrow opener where it is delivered to the soil covered and packed similarly to the seeders previously described.

To determine the proper rate of seeding, the seeder is calibrated for each kind or size of seed by turning the drive wheels to equal the ground travel of a given length of row and the seed thus delivered is weighed to determine the amount. Ten replicated tests with wheat to determine the accuracy of this method of calibrating the seeder indicated a variation of $1/10$ of a gram per rod row. This amount of variation would have practically no effect on the resulting yield of the crop as indicated by experiments which will be referred to later.

Capacity

The continuous single-row seeder will plant 1,000 to 1,200 single rod-rows per 10-hour day. This is much faster than the rod-row seeders previously referred to. The greater number of plots seeded is due to the fact that the hopper contains enough seed to sow 100 rod-rows. When the seed is changed, the hopper is readily emptied and is self cleaning so that little time is lost in changing from one variety to another. This seeder,

however, is not suitable for sowing single rod rows or shorter rows. The nine-inch fluted ring type of rod-row seeder is much more suitable for such work.

Rod-Row Seeder Endless Belt Type

Purpose

This machine was planned especially for testing different kinds of fertilizers and methods of applying it to various field crops. Various weighed quantities representing very light to heavy rates of application may be distributed evenly into moist soil at a specified depth in any length of row up to 22 feet. The machine is self cleaning so that as soon as one row of fertilizer is sown it is ready to receive fertilizer for the next row. The machine also sows seed of various cereals, grasses and legumes.

Description

The distinguishing feature of this machine is the endless rubber belt, 2 inches wide and 36 inches long. The rubber belt is stretched over 2 steel rollers 1 inch in diameter and spaced 20 inches apart centre to centre on an iron frame. A hopper is formed by 2 iron sides of the roller frame, with the top side of the rubber belt forming the bottom of the hopper. Fertilizer or seed is distributed by hand evenly on the endless rubber belt.



FIGURE 6. Endless Belt Seeder.

The portion of the belt to be covered depends on the length of row to be sown, this being determined by trial as with the 9-inch ring type seeder previously described. The endless belt is given motion by a 1-inch roller on the drive wheel axle. The drive wheels are 12 inches in diameter. The ratio of the belt speed to ground travel is 1 foot to 12 feet. As the machine is moved over the ground the fertilizer or seed is carried by the belt to a conductor tube at the front end of the machine when it is guided to the furrow opener and thence to the soil. It is then covered and packed as previously described for the 9-inch fluted ring seeder.

Capacity

The endless belt seeder will plant from

300 to 400 single rod rows per 10-hour day depending on soil and weather conditions.

Seeding by Weight vs. Numbers of Viable Kernels

The usual method of seeding grain is to sow by weight or measure expressed in terms of pounds or bushels per acre, as sown by the ordinary grain drill. Some experimenters consider it advisable to sow as nearly as possible an equal number of viable seeds in each row or plot when testing varieties in order that the test may be as uniform as possible in this respect, since seeds may vary greatly in size and viability. This is known as the Swedish method. In actual practice the seed is generally weighed, the weight per rod row being calculated on the basis of the 1,000 kernel weight and the percentage germination. It differs mainly from the ordinary method of seeding, namely by rate, by the consideration of the 1,000 kernel weight, as the viability of the seed is nearly always considered whatever method is adopted to determine the rate to sow.

Kiesselbach and many other experimenters have conducted experiments which indicate that the rate of seeding of a given variety can vary considerably without materially affecting the resulting yield. An experiment conducted at the Swift Current Experimental Station during the past five years shows that the rates of seeding of wheat, oats and barley can vary very widely with little influence on yield when weeds do not compete seriously. For instance, single kernels of wheat spaced $\frac{3}{4}$ inch, 1 inch, $1\frac{1}{4}$ inch and $1\frac{1}{2}$ inches apart gave average yields for a period of five years of 23.5, 22.9, 22.6 and 22.3 bushels per acre respectively. In other words, four rates of seeding varying approximately from one bushel to two bushels per acre gave yields from 23.5 bushels to 22.3 bushels per acre. Expressed in other terms we may say that rates of seeding varied as much as 100%, influenced the yield only to the extent of 5.1%. It is quite apparent that cereal crops are able to adjust themselves to widely varying conditions. Examination of data of rates of seeding experiment



FIGURE 7. Seeding increase plots $3\frac{1}{2}$ ft. \times 3 ft. with the Rod Row Seeder.

conducted at the Swift Current Experimental Station in 1926 showed clearly that the grain crops were able to compensate for heavy or light rates of seeding by producing longer or shorter culms, few or many stools, longer or shorter heads with kernels also varying in size and number.

While experiments indicate that rates of seeding varying considerably have little influence on the resulting yield in the absence of competition by



FIGURE 8. Rod Row Plot of Cereal Varieties sown with Rod Row Seeder.



FIGURE 9. Depth of Sowing Brome Grass Experiment. Seeds sown at various depths with rod row seeder.

weeds, the yield data, though perhaps the most important consideration in a variety test, may not be the only important consideration in some experiments. Heavy or light seeding may affect time of maturity, susceptibility to such diseases as rust, length of straw, or the size and quality of the kernels. These are problems that require further experimental study. They are mentioned here since the method chosen for seeding plots may determine to some extent the type of seeder most suitable for the purpose.

Hand Seeding vs. Machine Seeding

Two important factors that are usually considered when determining the merits of hand seeding and machine seeding are: (1) The time required to seed a given number of rows; and (2) the quality of the work. Experiments have been conducted at the Swift Current Experimental Station to determine these points. Two types of seeders were compared with hand seeding! The machines used were the continuous row seeder of the fluted drum type and the rod-row seeder of the 9-inch fluted ring type. Hand seeding was aided by opening a furrow with a small hand plow, then distributing the seeds in the furrow by hand and covering with the plow or a hand rake. Wheat, oats and barley were used for the test. The time required for seeding by the various methods is as follows:

The continuous seeder was the fastest method of seeding by a considerable margin. However, the number of plots sown by this machine would average less per hour at the end of a ten-hour day if the replicates were randomized, since considerable time would be required for locating the randomized plots and also for changing seed. A more conservative estimate for sowing randomized plots with the continuous row seeder would be about 90 to 100 rows per hour.

| Method of seeding | Minutes per 36 rod rows | Rod rows per hour |
|-----------------------|-------------------------|-------------------|
| Continuous row seeder | 17 | 128.0 |
| Single rod row seeder | 42½ | 49.6 |
| Hand seeding | 73 | 29.6 |

The quality of the work by each method is indicated by the germination of the seed and the percentage stand of crop at harvest time. In the test conducted in 1929 the seed was sown on May 20. Fifty per cent of the seed sown by both the machines germinated, producing plants that reached above ground on May 27. Two days later these same plots obtained their maximum stand. The first seedlings of the hand-seeded plots did not show above the ground until June 20. The average percentage

stand of the crops sown by the different methods as they appeared at harvest are indicated in the following table:

| Method of seeding | Percentage stand at harvest, average of twelve rod rows | | |
|-----------------------|---|------|--------|
| | Wheat | Oats | Barley |
| Continuous row seeder | 90 | 85 | 75 |
| Single rod row seeder | 95 | 95 | 90 |
| Hand seeding | 35 | 45 | 75 |

While the continuous row seeder offers the quickest method of sowing rod row plots, the stands of barley and

oats are not as uniform as those obtained with the single rod row seeder of the 9-inch fluted ring type. This is due to the fact that the seeds of oats and barley vary considerably in size and shape, and the shape of oats, particularly, does not lend itself to automatic feed mechanism that can be calibrated very closely. The difficulty is minimized by sowing heavier rates. As a rule a seeder that is designed to sow oats satisfactorily will sow wheat and barley with little or no difficulty.

The single rod row seeder of the 9-inch fluted ring type has proven itself at Swift Current to be the most useful kind of seeder for nursery work because of its versatility. It may be used for seeding a wide range of seeds of different sizes and shapes in rows of any length up to 22 feet. It is adaptable for any of the seeding methods as space seeding, seeding by numbers of viable kernels, seeding by weight, or seeding by volume. The seed may be distributed to the hopper from packets or by a measure from a bulk lot. The packeting of seed before seeding effects systematic and efficient methods of seeding when used with the single rod row seeder.

Hand seeding has consistently proven to be a very slow and unsatisfactory method, particularly in dry seasons when poor germination and stands usually result in the loss of a season's work



FIGURE 10. Nursery Seeding Experiment. Hand seeding versus sowing with Rod Row Seeder and Continuous Row Seeder. Hand sown seed germinated very poorly.

HARVESTING

Extensive series of rod-row plots create a great amount of slow tedious work in harvesting when it is done by means of a sickle or a similar tool. In order to do this work more quickly, more conveniently, and to reduce the cost of labour several rod-row harvesting machines have been designed and constructed at Swift Current. Some were powered by a light weight

gas engine; others were pushed by hand. Those which were driven by engine power were too cumbersome and heavy, though the cutting mechanism was satisfactory. The cutting device was simply a 12-inch length of a hay mower knife. The addition of a gas engine also complicated the machine unnecessarily, as well as adding considerable to its weight and cost. Theoretically, the energy that can be supplied continuously by one man is sufficient to powerize a cutting device if it is properly applied. In 1931 it was observed that ordinary hedge shears with weighted handles would cut a single row of grain. The weighted handles were simply $3\frac{1}{2}$ foot lengths of $\frac{3}{4}$ -inch iron pipe. The handles were sufficiently heavy so that when one was allowed to fall by its own weight it supplied sufficient power to operate the shear to which it was attached and cut standing grain. This hedge shear type of cutter did not seem to lend itself very readily to the cutting of rod row plots mainly due to its mode of operation which made the work of cutting both awkward and slow. These difficulties may be eventually overcome. Because of the simplicity of the hedge shears further efforts are being made to make this form of cutter adaptable to rod row harvesting.

Rotary Shear Rod Row Cutter

Purpose

The rod-row harvester which is now in use at Swift Current is of the rotary shear type. It was designed to overcome the difficulties of the hedge shear type as already mentioned. The rotary shear affords a continuous cutting action and overcomes the slow spasmodic shearing action of the hedge shears. It is operated entirely by man power. This harvester is most suited to short and medium crops. Very rank growth may require some modification in design to cut the crop. The rotary shear however seems to be the most logical kind of cutting mechanism on which to base a suitable design.

Description

The rotary shear cutter consists of two flat disc-shaped steel knives three inches in diameter. The revolving knives are mounted on vertical spindles spaced so that the knives overlap about $\frac{3}{4}$ of an inch of their perimeter. The knives are also adjustable vertically on the spindle. The revolving knives are rotated through a set of mitre gears located in a specially shaped aluminium casting which forms also a sealed housing for gears, bearings and light transmission lubricant. The front part of the casting is made to form a "V" shaped opening into which the rows of grain are guided to be cut by the rotary shears. The entire machine is actuated by the ground wheels through a chain and sprocket drive which supplies power to the mitre gears and rotates the knives. A sheet metal basket is set between the handles to contain the cut grain. As the machine is pushed along the ground the rotary knives shear off the standing grain about three inches above the ground and the cut grain falls back into the metal receiving box between the handles.

Capacity

Two men using the machine can cut 1,500 rows per day. One man is required to push the cutter while the other guides the rows of grain by hand towards the hopper. This is not always necessary when the grain

is standing erect. When the row is cut, one man lifts the cut grain from the receiving box and holds it while the second man ties the bundle and labels it. The labels are prepared before harvest time.

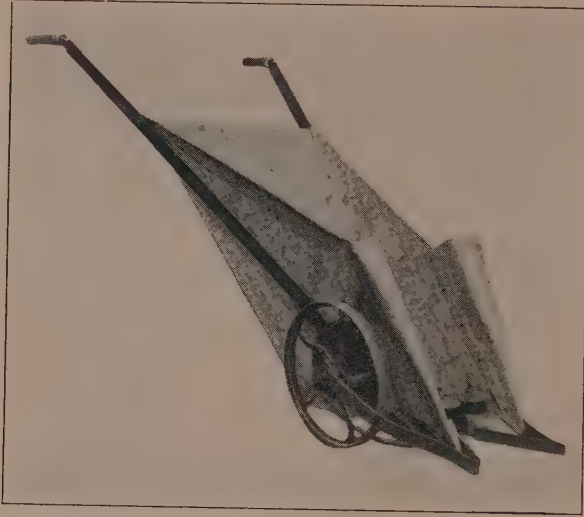


FIGURE 11. Rotary Shear Rod Row Cutter.
Front view.

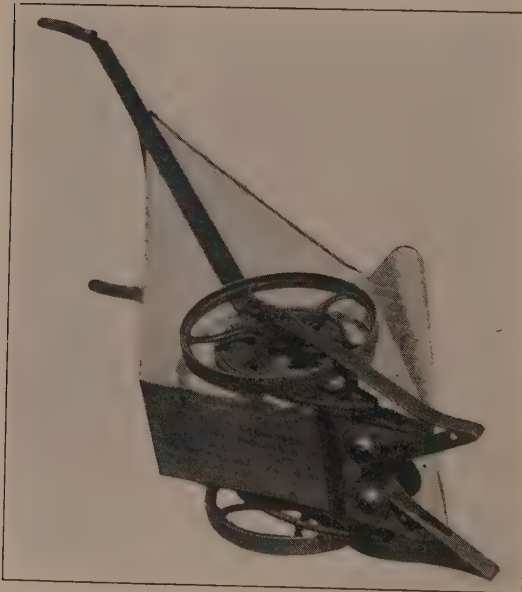


FIGURE 12. Rotary Shear Rod Row Cutter
View of underside (11).

THRESHING

Rod Row Thresher

Purpose

As with seeding and harvesting, a large number of small plots entails a great deal of work in threshing. To do this work a small thresher of simple design constructed so as to avoid lodging of grain and consequent mixing is an important requisite. Such a machine should thresh, clean and deliver the grain ready for weighing and also be self cleaning after each lot is threshed. The machine here described has been designed with these aims in view.

Description

The rod row thresher is of all-metal construction with the exception of the pitman arm and some bearing support blocks which are made of hardwood. Special castings are used in the construction of the machine. The thresher without the feed table is 7 feet long, $2\frac{1}{2}$ feet wide and $5\frac{1}{2}$ feet high. The frame construction of the machine consists of $1\frac{1}{4} \times \frac{3}{16}$ -inch angle steel re-inforced with $\frac{1}{8}$ -inch steel gusset plates. The feed table and cylinder are located at the top and at one end of the steel frame.

The cylinder housing is formed by specially designed iron castings. A heavy flat face cast iron pulley fitted with teeth is used for the threshing cylinder. The size of the pulley is 10 inches in diameter, 10-inch face, $1\frac{7}{8}$ -inch bore, and fitted with two set screws. The face of the pulley is drilled and tapped to receive eight rows of teeth. The teeth are made from $\frac{1}{2} \times \frac{1}{2}$ square cold rolled steel threaded at one end with a $\frac{3}{8}$ -inch standard thread. The teeth are screwed into the tapped holes on the face of the pulley and secured on the underside of the pulley face with a lock washer and nut. The teeth are spaced $1\frac{19}{64}$ -inches apart on centres so that the space between the cylinder and concave teeth is almost $\frac{5}{32}$ of an inch. After the teeth have been screwed into the cylinder, the cylinder is placed in a lathe to true up the sides and ends of any teeth that may be slightly out of alignment. The cylinder is then balanced while it is between the lathe centres. Four rows of $\frac{3}{4}$ -inch concave teeth are screwed into a semicircular cast iron concave plate. The spacing of the teeth is similar to that of the cylinder teeth except that the rows are closer together being $2\frac{1}{8}$ inches apart. The concave plate forms also the top part of the cylinder housing. The concave teeth are thus inverted, and being located in this position above the cylinder, prevent grain and straw from lodging in the concave teeth and save the necessity of frequently cleaning out. In order to prevent grain getting inside the cylinder, the sides of the cylinder are recessed into the sides of the cylinder housing $\frac{1}{8}$ of an inch with a clearance of $\frac{1}{32}$ inch. A $1\frac{7}{8}$ cylinder shaft is turned down at the ends to $1\frac{3}{8}$ inch diameter to fit the ball bearing located in the hub projections on the side of the cylinder housing.

The threshed grain and straw pass from the cylinder down into an oscillating chute. This chute is made of galvanized iron with seams half way up the sides to provide a smooth bottom free from crevices. One end of the bottom of the chute is formed of 22 metal louvres. Fourteen of the louvres nearest to the cylinder are spaced to provide openings $\frac{1}{2}$ inch wide. These separate the threshed grain from the straw. The remaining eight louvres are spaced to provide openings $\frac{7}{8}$ inch wide. These allow

unthreshed heads and grain that may escape from the first set of louveres to be trapped into a tailing box below. The remaining straw passes out of the end of the chute. The louveres form the only screening mechanism for separating the grain from the straw. Their design affords considerable strength, but is also plain and simple, and made so expressly for the purpose of reducing to a minimum the opportunity of straw or heads to lodge, so that cleaning out at this part of the machine is seldom required. The separation of the grain from the straw and chaff is aided by a controlled blast of air supplied by a $3\frac{1}{2}$ -inch forge blower located at the cylinder end of the machine. The air is directed through a pipe 24 inches long to within 30 inches of the louveres. The distance between the end of the pipe and the louveres allows the blast of air to spread before it strikes the lips of the louveres. The lips of the louveres deflect the air currents into the chute so that the straw and chaff are carried out at the end of the chute. The threshed grain which falls through the half inch louveres drops into a funnel shaped receptacle below which guides it into a sloping 4-inch pipe. Here the grain is recleaned by a controlled blast of air supplied by a $2\frac{1}{2}$ -inch pressure blower the outlet of which is connected with the sloping 4-inch pipe. The air blast is directed upward against the descending grain and the chaff is carried over to the tailings box.

Operation

In operating the thresher, the cylinder is driven at a speed of about 1,000 r.p.m. The pitman eccentric shaft rotates 200 r.p.m. to oscillate the conveyer chute. Both the pressure blowers are given a speed of 2,000 r.p.m.

The actual operation of threshing the grain consists of feeding small sheaves evenly to the cylinder after the bands and labels are removed. All the straw is allowed to go through the machine. The threshed grain and straw pass from the cylinder to the conveyer chute. Threshed grain falls through the first set of louveres and drops down into the recleaner on its way to the receiving pan at the bottom of the machine. Unthreshed heads then passed through a second set of louveres are caught in the tailings box and handed back to the cylinder to be re-threshed or through the back end of the chute to be recleaned. The remaining straw and chaff is delivered out at the end of the conveyer chute.

Three men are required to operate the machine to full capacity. One feeds the machine, the second returns the tailings to the feeder and empties the grain receiving pan after each lot is threshed. The third man weighs the samples and records the weights and other data such as the weight per measured bushel.

Peas and beans may be threshed by belting the machine so that the cylinder runs in an opposite direction at about 200 r.p.m., to avoid contact with the concave teeth, but the conveyor chute and the fans must be belted to run at their normal speed and the fans in the proper direction. Running the cylinder backwards at a slow speed avoids cracking the seeds.

This machine is now manufactured by the Vulcan Iron Works, Winnipeg, Manitoba, Canada.

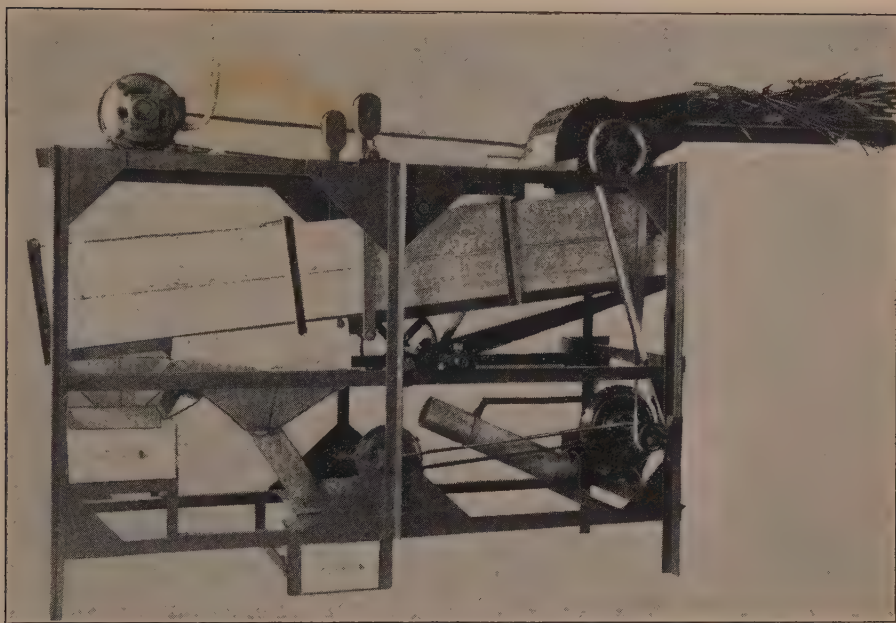


FIGURE 13. Cereal Nursery Thresher for Rod Row Plots and small lots of grain.

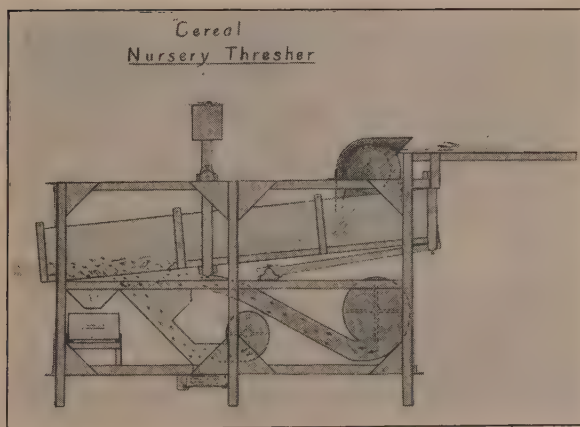


FIGURE 14. Diagram of Cereal Nursery Thresher.

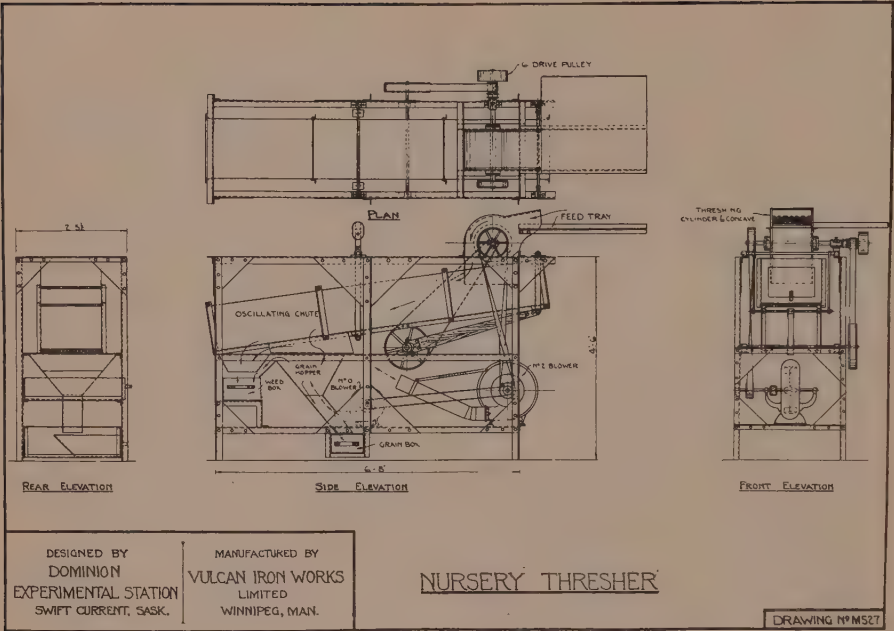


FIGURE 15. Assembly Plan of Cereal Nursery Thresher.

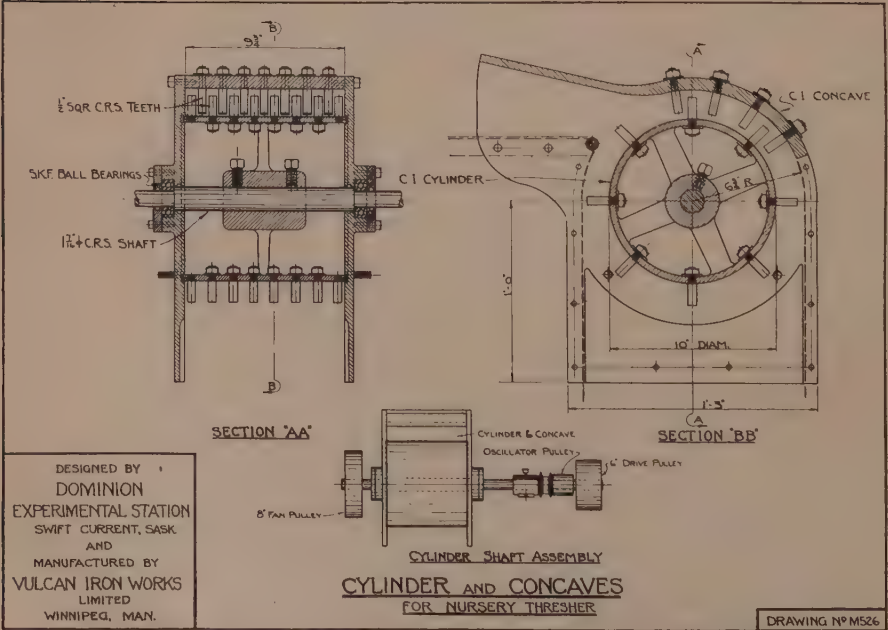


FIGURE 16. Plan of Cylinder and Housing of Cereal Nursery Thresher.

Head Thresher

Purpose

Single heads or the product of short rows as head rows are threshed with this machine. The machine is self-cleaning so that a large number of single heads or small lots can be threshed and cleaned in rapid succession without the necessity of cleaning out between each sample.

Description

The machine is about 30 inches high and mounted on a wood base 30 inches long and 14 inches wide. On the top part of the thresher is a funnel shaped entrance into which heads of grain are introduced for threshing. Directly below the feed chute is the cylinder housing which encloses a solid steel cylinder 4 inches in diameter and 4 inches long. The cylinder is recessed into the sides of the cylinder housing to prevent lodging of grain or chaff. Six rows of teeth made from $\frac{3}{8}$ -inch square cold rolled steel are screwed into the cylinder. Three rows of teeth are used for the concave. The concave teeth are screwed into the top part of the cylinder housing so that the teeth are inverted forming what is sometimes called an "overshot" cylinder. As with the rod-row thresher the inverted concave teeth are used to prevent lodging and consequent mixing of seeds. The cylinder is carried on a $\frac{5}{8}$ -inch steel shaft which rotates on two ball bearings. These are the only bearings in the machine. The cylinder shaft also carries two 6-bladed fans, one on each side of the cylinder housing. The fans are enclosed. The air blast created by these fans is the only means provided for cleaning the grain. The cylinder and fans operate at speeds from 5,000 to 7,000 r.p.m. Below the cylinder is a 4 inch \times 4 inch vertical

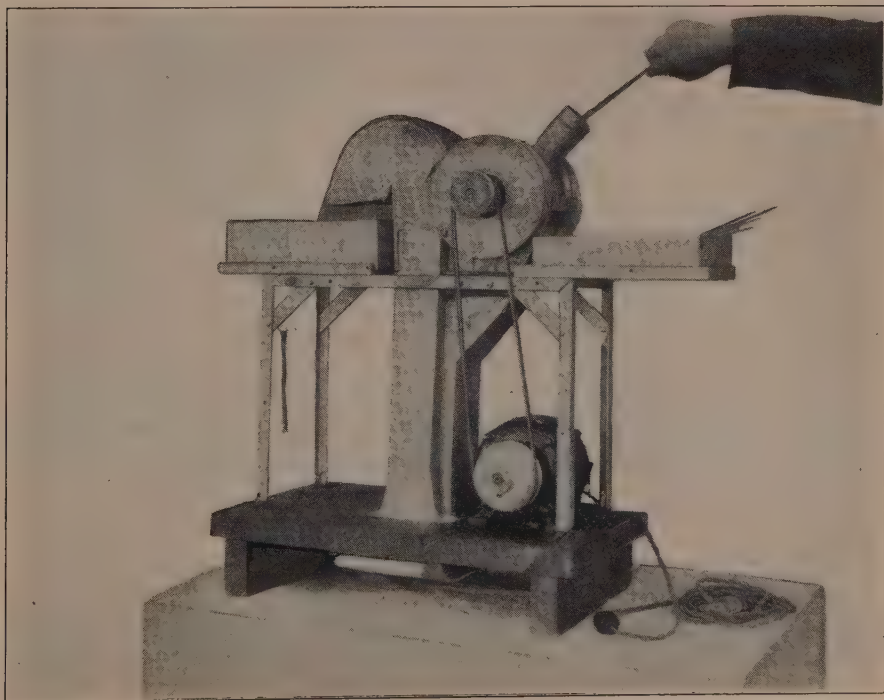


FIGURE 17. Head Row Thresher.

metal chute about 20 inches long which conveys the threshed grain and chaff toward the specially shaped grain pan at the bottom of the chute. The chute also forms the recleaning chamber. On each side of the 4 inch \times 4 inch chute is a smaller chute which conducts the air blast from the fans to the grain receiving pan. The bottom of the grain pan is rounded to deflect the air upwards through the 4 inch \times 4 inch square chute where it meets the threshed grain and chaff. The chaff is carried upward by the air blast and out of the machine at the top and into a screened receptacle. The grain continues to fall through the rising air currents to the receiving pan below. The two sources of air from the fans on each side of the machine together with the specially shaped grain pan is essential to overcome dead air pockets.

Operation

The heads are pushed through the funnel shaped chute to the revolving cylinder so that just the heads are threshed and the straw withdrawn. The heads are best handled when they have about 8 or 10 inches of straw, since the head can be held in the cylinder for a few seconds to secure good threshing. The threshed grain and chaff drop down the vertical chute where they are separated by the air blast. The threshed grain which falls into the grain pan is then put into suitable containers. Two men are required to operate the machine to full capacity. One man feeds the heads into the machine while the other receives the threshed grain and places it in numbered containers. Two men can thus thresh 200 heads per hour if the envelopes or other containers are previously numbered or otherwise prepared.

GERMINATION OF RUSSIAN PIGWEED SEEDS IN ICE AND ON FROZEN SOIL¹

O. S. AAMODT²

University of Alberta, Edmonton, Alberta

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Numerous studies have been made on the most suitable temperatures for the germination of seeds in seed testing laboratories. Little information exists on the subject of minimum temperatures for seed germination of our commonly grown crop plants and the weeds with which they must compete.

Some investigators have found in laboratory tests that the seeds of several of our crop plants, especially clovers and cereals, will germinate at or near freezing temperatures. Under field conditions germination of seeds does not proceed, as a rule, at such low temperatures owing to the brief duration of the favourable temperature and the extremes to which the temperature may fall at night. Unless the seedlings possessed natural resistance to freezing, they would probably fail to survive the low night temperatures.

In a study (1) on the effect of low temperatures on the survival of several cereal crop varieties and wild oats, observations were made in the field on their abilities to survive low temperatures under natural conditions. On March 16th, in the spring of 1934, before there was any indication of growth in either spring or winter cereal crops, the writer found seeds of Russian pigweed (*Axyris amaranthoides* L.) germinating and seedlings growing in pure ice and frozen soil (see Figure 1).

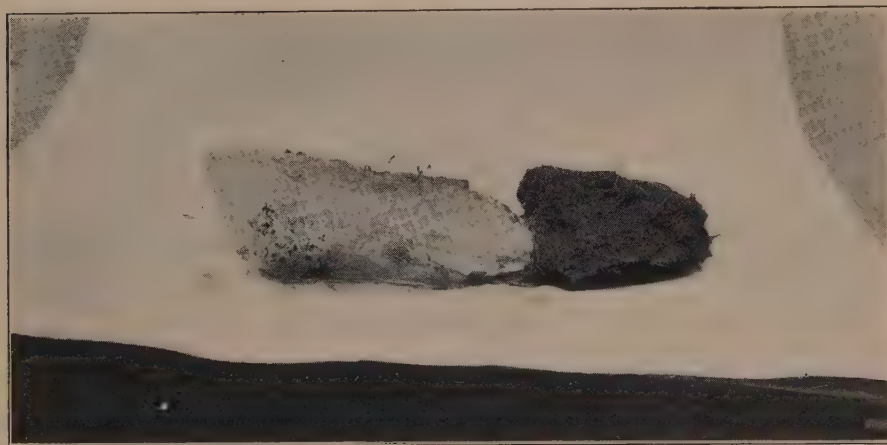


FIGURE 1. Russian Pigweed germinating in ice and on frozen soil. University of Alberta, Edmonton. March 16, 1934.

Mature plants, from the previous year's growth, containing numerous seeds were still standing erect. A portion of the ground underneath the plants was covered with heavy ice. Numerous Russian pigweed seeds had fallen from the dry plants to the ice and the frozen soil. The small black

¹ Contribution from the Department of Field Crops, University of Alberta, Edmonton, Canada.

² Professor of Genetics and Plant Breeding.

seeds that fell on the clear ice appeared to have absorbed heat from the sun's rays and to have melted their way into the ice. The heat liberated in respiration of the seed may also have been a factor, especially after germination had begun. These seeds were found at depths in the ice varying from one-eighth to one inch. In each case the path that the seed had travelled through the ice was evident from the cylindrical hole slightly larger than the diameter of the seed, and extending from the seed to the surface of the ice. In many instances the seeds had germinated in the bottoms of these cavities and the seedlings had elongated sufficiently to emerge above the surface of the ice as shown on the left in Figure 1.

The surface of the soil not covered with ice thawed out to a depth of approximately one-eighth of an inch during the day. Russian pigweed seeds falling on this surface appeared to have germinated readily as shown on the right in Figure 1. Those seedlings that started in the ice continued normal growth as soon as the ice melted and they made a contact with the soil beneath.

The climatic conditions prior to the development of the Russian pigweed seedlings may be of interest. The maximum and minimum air temperatures and the precipitation for the fifteen days previous to the

TABLE 1

| Date | Temperature in degrees F. | | Precipitation in inches | |
|---------|------------------------------|---------|----------------------------|-------|
| | Maximum | Minimum | Snow | Rain |
| March 1 | 45 | 32 | — | Trace |
| 2 | 48 | 33 | — | — |
| 3 | 42 | 26 | — | — |
| 4 | 30 | 24 | — | — |
| 5 | 20 | 11 | — | — |
| 6 | 23 | 10 | 1.50 | — |
| 7 | 27 | 3 | .25 | — |
| 8 | 16 | 5 | .10 | — |
| 9 | 47 | — 5 | — | — |
| 10 | 60 | 5 | — | — |
| 11 | 62 | 35 | — | — |
| 12 | 40 | 40 | — | — |
| 13 | 42 | 19 | — | — |
| 14 | 48 | 26 | — | Trace |
| 15 | 25 | 24 | 1.25 | — |
| 16 | 18 | 6 | .25 | — |

time of the observation were as shown in Table 1.

There was bright clear sunshine most of the day time for the first half of March when it was not snowing or raining. Most of the snow fell during the night and melted during the day. On several occasions the night temperatures fell considerably below freezing, and on March 9th as low as 5° F. below zero. In spite of these extreme conditions the seedlings survived and produced strong healthy plants.

In some of the short season areas, and in years in which there is a late spring, field crops, especially cereals, are often sown without a previous cultivation of the soil. Weed seeds that are able to germinate at low temperatures, and that will survive freezing temperatures during germination and in the seedling stages, have a great advantage in becoming established before the crop is sown. Definite and more extensive information on the minimum temperatures at which seeds of our crop plants and common weeds germinate would be of great value.

REFERENCE

1. AAMODT, O. S. and PLATT, A. W. Resistance of wild oats and some common cereal varieties to freezing temperatures. *Sci. Agric.* 14 : 645-650, 1934.

THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY
THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT
OF AGRICULTURE, OTTAWA

Vol. V, No. 1.

March, 1935

THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF
AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY
THE DOMINION BUREAU OF STATISTICS

Wholesale prices in Canada showed a gain of four and one-half points in 1934 compared with 1933. The increase in farm products was about eight points, being almost evenly divided between field products and animal products. In the month of January, wholesale prices in general advanced slightly. On the other hand the index or prices of farm products was a little lower. Recession in field products more than offset a small gain in prices of live stock products. It will be noted that retail prices advanced about one point in 1934 and the index stood at 78.9 in January, 1935.

Employment.—The increase in employment as at February 1 was less than normal. The index, therefore, receded to 99.9, compared with 101.2 as at January 1. It should be noted, however, that the seasonal recession at the beginning of January was less than normal and, therefore, an increase at the first of February of less than normal proportions is not considered to be a serious matter. Employment was more active at February 1, 1934, in all economic areas except the Maritime Provinces.

Physical Volume of Business.—The physical volume of business showed a substantial gain in January, the index rising to 96.5. Industrial production advanced from 91.0 in December to 96.3 in January. Mineral production and manufacturing were lower. Iron and steel production displayed considerable activity. Construction showed a substantial gain, contracts awarded rising from 31.5 to 92.8. Building permits were lower and cost of construction rose slightly. The total index was 71.3 compared with 31.2 in December. Electric power production increased. Agricultural marketings continued to decline, the index of grain marketings being 19.3. Live stock marketings on the other hand advanced from 67.3 to 81.5, an increase in shipments of cattle, calves, and sheep being responsible for the gain. The index of cold storage holdings rose from 135.7 to 143.7.

Provisional averages for the physical volume of business in 1934 show a substantial increase in business activity in 1934 compared with 1933. The total index was 94.2 during the past year while in 1933 it was 79.7. In fact the annual average index in 1934 was higher than in any year since 1929. The same was true of the index of industrial production. Agricultural marketings were much below those of 1933, however, the index dropping from 105.1 to 88.5. The index of grain marketings was 90.2, while that of live stock was 80.5. Cold storage holdings on the whole showed little change compared with 1933.

Wages of Farm Help.—The average monthly wage paid for male help during the summer season of 1934 is reported by the Agricultural Branch of the Dominion Bureau of Statistics to have been \$18 compared with \$17 in 1933, \$19 in 1932 and \$25 in 1931. The value of board supplied was estimated at \$15 per month, 1934 to 1932, and at \$18 in 1931. The estimated total of wages and board was, therefore, \$33 during the past year, \$32 in 1931, \$34 in 1932 and \$43 in 1931.

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION
COMPUTED BY DOMINION BUREAU OF STATISTICS

| Year | Wholesale Prices 1926 = 100 | | | | Retail prices and cost of services (5) | Production (6) 1926 = 100 | | | |
|-------|-----------------------------|-------------------|--------------------|---------------------|--|-----------------------------|-----------------------|-------------------------|-----------------------|
| | All commodities (1) | Farm products (2) | Field products (3) | Animal products (4) | | Physical volume of business | Industrial production | Agricultural marketings | Cold Storage holdings |
| 1913 | 64.0 | 62.6 | 56.4 | 77.0 | 65.4 | | | | |
| 1914 | 65.5 | 69.2 | 64.9 | 79.0 | 66.0 | | | | |
| 1915 | 70.4 | 77.7 | 76.9 | 79.2 | 67.3 | | | | |
| 1916 | 84.3 | 89.7 | 88.4 | 92.3 | 72.5 | | | | |
| 1917 | 114.3 | 130.0 | 134.3 | 119.6 | 85.6 | | | | |
| 1918 | 127.4 | 132.9 | 132.0 | 134.7 | 97.4 | | | | |
| 1919 | 134.0 | 145.5 | 142.4 | 152.5 | 107.2 | 71.3 | 65.5 | 48.1 | 47.1 |
| 1920 | 155.9 | 161.6 | 166.5 | 149.9 | 124.2 | 75.0 | 69.9 | 52.6 | 94.2 |
| 1921 | 110.0 | 102.8 | 100.3 | 108.5 | 109.2 | 66.5 | 60.4 | 65.2 | 86.4 |
| 1922 | 97.3 | 86.7 | 81.3 | 99.1 | 100.0 | 79.1 | 76.9 | 82.6 | 82.8 |
| 1923 | 98.0 | 79.8 | 73.3 | 95.1 | 100.0 | 85.5 | 83.8 | 91.4 | 87.6 |
| 1924 | 99.4 | 87.0 | 82.6 | 97.2 | 98.0 | 84.6 | 82.4 | 102.5 | 114.9 |
| 1925 | 102.6 | 100.4 | 98.1 | 105.7 | 99.3 | 90.9 | 89.7 | 97.2 | 108.6 |
| 1926 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1927 | 97.7 | 102.1 | 99.9 | 105.7 | 98.4 | 106.1 | 105.6 | 103.6 | 110.0 |
| 1928 | 96.4 | 100.7 | 92.6 | 114.3 | 98.9 | 117.3 | 117.8 | 146.7 | 112.8 |
| 1929 | 95.6 | 100.8 | 93.8 | 112.5 | 99.9 | 125.5 | 127.4 | 101.1 | 109.6 |
| 1930 | 86.6 | 82.3 | 70.0 | 102.9 | 99.2 | 109.5 | 108.0 | 103.0 | 128.4 |
| 1931 | 72.2 | 56.3 | 43.6 | 77.6 | 89.6 | 93.5 | 90.4 | 99.0 | 125.7 |
| 1932 | 66.7 | 48.4 | 41.1 | 60.7 | 81.4 | 78.7 | 74.0 | 114.3 | 120.1 |
| 1933 | 67.1 | 51.0 | 45.8 | 59.6 | 77.7 | 79.7 | 76.8 | 105.1 | 115.4 |
| 1934 | 71.6 | 59.0 | 53.9 | 67.6 | 78.9 | 94.2 | 93.6 | 88.5 | 114.2 |
| 1934 | | | | | | | | | |
| Jan. | 70.6 | 55.3 | 47.9 | 67.8 | 78.2 | 86.8 | 84.5 | 48.2 | 108.1 |
| Feb. | 72.1 | 58.0 | 49.3 | 72.5 | 78.7 | 86.4 | 84.0 | 67.1 | 98.6 |
| Mar. | 72.0 | 56.5 | 49.5 | 68.3 | 79.9 | 93.1 | 92.0 | 63.8 | 97.0 |
| Apr. | 71.1 | 55.4 | 48.7 | 66.6 | 79.4 | 92.6 | 91.4 | 56.9 | 94.5 |
| May | 71.1 | 56.9 | 51.1 | 66.5 | 78.5 | 99.6 | 99.4 | 130.6 | 102.6 |
| June | 72.1 | 59.3 | 55.5 | 65.6 | 78.2 | 95.8 | 95.2 | 97.2 | 126.1 |
| July | 72.0 | 60.0 | 57.8 | 63.7 | 78.4 | 95.7 | 95.6 | 148.8 | 116.3 |
| Aug. | 72.3 | 61.6 | 60.7 | 63.1 | 78.7 | 99.0 | 99.8 | 172.8 | 114.7 |
| Sept. | 72.0 | 61.3 | 58.9 | 65.3 | 79.0 | 97.1 | 97.5 | 127.7 | 117.7 |
| Oct. | 71.4 | 60.9 | 55.3 | 70.4 | 79.3 | 95.8 | 95.3 | 61.2 | 128.8 |
| Nov. | 71.2 | 61.2 | 55.7 | 70.4 | 79.4 | 96.5 | 97.0 | 51.2 | 130.4 |
| Dec. | 71.2 | 61.6 | 56.0 | 70.9 | 79.0 | 92.4 | 91.0 | 36.0 | 135.7 |
| 1935 | | | | | | | | | |
| Jan. | 71.5 | 61.4 | 55.7 | 71.0 | 78.9 | 96.5 | 96.3 | 30.6 | 143.7 |

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1932, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1932, p. 32, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries. See Prices and price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

In 1934 the monthly wage of men employed on farms was highest in British Columbia where it averaged \$43 and was lowest in Prince Edward Island and Quebec in which provinces the average wage was \$30 per month.

Wages of men employed by the year averaged \$171 in 1934, compared with \$161 in 1933, \$176 in 1932, and \$240 in 1931. Allowances for board were \$167, \$161, \$165, \$199 respectively in the four years for which this comparison has been made. Thus the combined value of wages and board was \$338 in 1934, \$322 in 1933, \$341 in 1932, and \$439 in 1931. The total cost of year help in 1934 was, therefore, just about \$100 less than in 1931.

ACTS OF INCORPORATION OF CO-OPERATIVE ASSOCIATIONS IN CANADA

A. E. RICHARDS¹

One of the main objects of a co-operative association is to effect savings in the marketing of farm products or the purchasing of supplies. Its membership is usually confined to those who patronize the association. Other distinctive features are a limitation on the ownership of shares of capital stock, one vote per member, a moderate rate of return on capital within definite limits, and the disposition of any surplus, after reserves have been provided for, in proportion to patronage. By enacting statutory laws governing the establishment of co-operative associations governments have given recognition to the usefulness of this type of organization in the economic life of the community.

Records received by the Economics Branch from farmers' business organizations throughout Canada show that out of 809 associations reporting, 757 or 94% are incorporated. While a number of companies have received their charters by special acts, the great majority are incorporated under provincial co-operative associations acts. This large percentage of incorporated co-operative associations, which includes 2,000 local branches and represents over 3,000 places of business, is to be commended as it shows business foresight and a realization of the responsibilities of business enterprise on the part of co-operative leaders and officials.

The co-operative associations acts establish the legal status of an organization, determine its powers and limitations, and chart a general course of procedure to which an association incorporated under such acts must conform.

The application to organize a co-operative which is usually termed a memorandum of association must be signed by a responsible group of persons who are initiating the organization and deposited in the office of the Provincial Secretary, Registrar of Companies or Registrar of Co-operative Associations. The memorandum must state the name of the proposed association, designate the place of business, the objects of the association, the amount and kinds of capital stock and the value of shares.

The by-laws which must comply with the act are the common rules applying to a particular company which are adopted by the membership. These rules govern membership relations. Such matters as the bonding of officers and employees handling funds of the association, the setting of the fiscal year, provision for dividends if any, and provision for amendments are contained in the by-laws. For trading associations the inclusion of a clause dealing with the policy of the association in regard to cash sales or limitations upon credit is important.

If the memorandum and rules appear to the Registrar to comply with the act, he issues a certificate showing that the association is incorporated and a copy of this certificate with a statement of the objects of the association are published, for a stated period of time in the provincial Gazette. This certificate of incorporation is evidence that the requirements of the act in respect to incorporation have been complied with, and that the association is duly incorporated and authorized to carry on business.

Incorporation provides a number of safeguards to business enterprises which are made legal by statutory law. It creates a corporation separate and distinct from the membership which composes the association. It establishes the principle of limited liability. Thus, if the incorporated company by some misfortune falls into heavy debt, suit for the recovery of the debt must be brought against the company and not against the individual members which compose it except for the amount remaining unpaid on their membership fees or subscriptions for shares. Limited liability obtained through incorporation facilitates the raising of capital. Other desirable and protective features of incorporation are that real estate and other property may be owned and transferred in the name of the company and the property interest of its members is made definite and more easily transferable.

¹ Agricultural Economist, Economics Branch, Department of Agriculture, Ottawa.

ESSENTIAL FEATURES OF PROVINCIAL CO-OPERATIVE ASSOCIATIONS ACTS

| | British Columbia Co-operative Associations Act R.S.B.C. 1924 | Alberta Co-operative Marketing Associations Act 1924 | Alberta Co-operative Associations Act R.S.A. 1922 |
|-----------------------------------|---|--|--|
| 1. Formation | Five or more persons. Name must include word "Co-operative." Must not include word "Company" or "Limited." | Ten or more persons. May be formed with or without capital. | Ten or more persons. Shall include word "Limited." |
| 2. Capital | Unlimited. Number of shares of such denomination as may be fixed by the memorandum. | Common and preference shares provided for. Memorandum must state number and value. | Unlimited. Memorandum must state number and denomination. |
| 3. Stock-holding privileges | Member may hold any number subject to provisions of rules. Must be paid for in cash. No share to be issued at a discount. | Limited per shareholder to one-twentieth of total number of ordinary shares. | Regulated by by-law. |
| 4. Redemption of shares | May redeem and re-issue its own shares. | May redeem shares provided debts do not exceed 50% of assets. | May re-purchase shares. |
| 5. Limitation of dividend | 8%. | 8% on ordinary and preference shares. | No provision. |
| 6. Dividend to non-member patron. | Yes. | No provision. | No provision. |
| 7. Patronage refund. | Yes. | Yes. | No provision. |
| 8. Borrowing powers | May borrow and raise money and may issue debentures for same. | May borrow money and issue bonds and debentures. | May raise money by mortgage and other assurances. |
| 9. Eligibility for membership | Open to anyone who complies with rules of the association. | Limited to persons engaged in agricultural production. Tenant or landlord receiving share of crop as rental. | Open to anyone who complies with the rules of association and purchases a share. |
| 10. Liability of members | Individually limited to amount unpaid on shares. | Individually limited to amount unpaid on membership fee or share subscription. | Individually limited to amount unpaid on shares. |
| 11. Loans to members | May advance money to members on security of real and personal property. | Yes. | Yes. On security of real or personal property. |
| 12. Voting | One member, one vote. Voting by proxy allowed, subject to rules. | One member, one vote. Proxy and mail voting allowed, subject to rules. | One vote per member by ballot. |
| 13. Marketing contract | Yes. | Yes, term limited to 7 years. | |
| 14. Breach of contract | Liquidated damages may be fixed and association entitled to injunction privileges and to an order for specific performance. Penalty for procuring breach. | No provision. | |
| 15. Apportionment of surplus | Not less than 10% to be placed in reserve fund until fund reaches 30% of paid-up capital or as provided in the Act. | To proper reserves. | To any lawful purpose. |
| 16. Auditors | Appointed by association. | Auditor appointed must be approved by Minister. | Two or more persons appointed as the rules provide. |
| 17. Annual Report | Must be filed with Registrar. | Must be filed with Registrar and available to members. | Must be filed with Registrar and available to members. |
| 18. Registration fee | \$10.00. | \$5.00. | \$5.00. |

| | Saskatchewan Co-operative Marketing Associations Act R.S.S. 1930 | Saskatchewan Co-operative Associations Act R.S.S. 1930 | Manitoba Co-operative Corporations Act 1932 |
|----------------------------------|---|---|---|
| 1. Formation | Ten or more persons. Words "Co-operative" "Marketing," "Association," "Limited," must form part of name. | Five or more persons. "Co-operative Association Limited" shall be the last three words of name. | Seven or more persons. Word "Co-operative" must be included in name and "Limited" if company has share capital. |
| 2. Capital | Unlimited. Memorandum must state amount of share capital and denomination of each share. Governed by by-laws. Shares can only be held by members. | As set forth in memorandum. | Preference and ordinary shares provided for. |
| 3. Stock-holding privileges | May redeem shares provided debts do not exceed 50% of assets. | No restriction, governed by rules. | Limited per shareholder to one-twentieth of total number of ordinary shares. |
| 4. Redemption of shares | 8%. | May redeem all but one share per member. | May redeem shares provided debts do not exceed 50% of assets. |
| 5. Limitation of dividend | No provision. | 6%, subject to by-law. | 7%. |
| 6. Dividend to non-member patron | Yes. | Yes. Remainder of surplus distributed in proportion to volume of business. | Credited on account of capital stock or membership fee. |
| 7. Patronage refund | Yes. | In accordance with Companies Act. | Yes. Remainder to be divided among members in proportion to volume of business. |
| 8. Borrowing powers | May borrow money and issue bonds and debentures. | Open to anyone who complies with rules of the association. | In accordance with Companies Act. |
| 9. Eligibility for membership | Limited to persons engaged in agricultural production. Tenant or landlord receiving share of crops as rental. | Limited to amount unpaid on shares. Lien on members share permitted for collection of debt. | Shall be producers of commodity proposed to be marketed in marketing association. |
| 10. Liability of members | Individually limited to amount unpaid on membership fee or share subscription or promissory note. | One member, one vote. No proxy voting allowed. | Individually limited to amount unpaid on share subscription or membership fee. |
| 11. Loans to members | May advance money to members on agreed terms. | In accordance with Companies Act. | No provision. |
| 12. Voting | One member, one vote. May vote by mail. No proxy voting allowed. | One member, one vote. No proxy voting allowed. | One member, one vote. No voting by proxy except in case of Branch representatives. |
| 13. Marketing contract | Yes, term limited to 7 years. | | Yes. |
| 14. Breach of contract | Liquidated damages may be collected. Penalty for inducing breach of contract \$50.00 to \$200.00. | 10% to be placed in reserve until fund equals 30% of paid-up capital stock. | Entitled to injunction and specific performance. |
| 15. Apportionment of surplus | To proper reserves. | Accounts must be audited. | 10% to be placed in reserve until fund equals 30% of paid-up capital stock. |
| 16. Auditors | Submit accounts for audit by chartered accountant. | Must be made to Registrar and available to members. | Regulated by memorandum of agreement. |
| 17. Annual Report | Must be made to Registrar and available to members. | \$1.00. | Must be filed with Provincial Secretary. |
| 18. Registration fee | \$10.00. | | \$12.50 up. |

| | Ontario Co-operative Corporations Act R.S.O. 1927 | Quebec Co-operative Agricultural Associations Act / R.S. 1922 | Nova Scotia Fruit, Produce and Warehouse Assn's. Act R.S.N.S. 1923 |
|-----------------------------------|---|--|---|
| 1. Formation | Five or more persons. Word "Co-operative must be part of name. | Twenty-five or more persons known as "shareholder-producers. Affiliated producers pay \$2.00 annual fee. Cannot attend general meetings or vote. | Five or more persons. "Limited must be included as last word in name. |
| 2. Capital | May be in form of share capital or capital notes from members, payable on demand. | Preference and ordinary shares. Amount of each \$10.00. Holders of preferred shares cannot attend or vote at general meetings. | Not less than \$1,000.00 of which one-half shall be subscribed. Capital stock increased by two-thirds vote. |
| 3. Stock-holding privileges | No restriction. | Maximum holding per member—ten shares. | No limitation, governed by rules. |
| 4. Redemption of shares | No provision. | Minimum holding—five shares. | No provision. |
| 5. Limitation of dividend | 8% per annum. | Preferred shares only, redeemable 7% limit on preferred shares. | No limitation, governed by rules. |
| 6. Dividend to non-member patron | | No provision. | No provision. |
| 7. Patronage refund | Yes. In proportion to volume of business. To non-members at such proportionate rate as determined by by-laws. | | |
| 8. Borrowing powers | In accordance with Companies Act. | Limited to an amount equal to four times aggregate amount of subscribed shares and reserve fund. | May borrow, execute mortgages and issue debentures, and pledge debentures as security for loans. |
| 9. Eligibility for membership | No restriction. | Must be producers. | No restriction. |
| 10. Liability of members | Limited to amount of unpaid portion of capital note, or share. | Limited to amount of holding. | Limited to amount unpaid on shares. |
| 11. Loans to members | Prohibited by Companies Act. | No provision. | No provision. |
| 12. Voting | One member, one vote. No proxy voting except in case of Branch representatives. | One vote per member. No proxy voting. | One vote for each share held. |
| 13. Marketing contract | No provision. | Provided for in by-laws. | Has power to regulate sale of members product. |
| 14. Breach of contract | No provision. | To proper reserves and remainder credited to shareholder-producers on account, on preferred shares. | Penalties can be collected. |
| 15. Apportionment of surplus plus | Up to 20% may be set aside annually in reserve and 5% in educational fund. | | May be placed in reserve fund. |
| 16. Auditors | Appointed by association. | Accounts must be audited by an auditor. | Governed by by-laws. |
| 17. Annual Report | Must be filed with Provincial Secretary. | Copy must be sent to Minister of Agriculture. | As provided in by-laws. |
| 18. Registration fee | Subject to Order-in-Council. | | No fee. |

As the result of incorporation, serious responsibilities devolve upon the directors as trustees of the shareholders. They should inform themselves on the responsibilities which they assume. On the part of the shareholders or members, due discretion should be exercised to assure the election of capable men to act as directors.

It is impossible in a brief review to discuss separately the co-operative associations acts of the provinces. They are set out in the foregoing pages under headings for comparison. It will be noted that certain underlying principles are common to all although the definition of powers is much more explicit and their application permits a larger scope of activity under the acts of certain provinces than of others.

Since all of the acts are designed to serve the same purpose, greater uniformity of provisions and wording of clauses should clarify interprovincial relations and would facilitate any Dominion-wide undertaking of a co-operative character. In the Maritime Provinces, acts have been framed to suit certain commodity groups and do not permit of general application. The Co-operative Union of Canada which represents a large body of consumer co-operative activity and opinion and representative co-operative marketing groups in the Dominion have given consideration to this problem and have urged the implementing of Dominion legislation.

In certain provinces the existing acts do not meet the needs of consumer co-operatives to the same extent as marketing associations and may account in some degree for the lack of progress in this type of co-operative activity. Records in the Economics Branch show that at the present time, in terms of places of business and total membership, marketing organizations outnumber purchasing associations of farmers by 10 to 1. In the matter of volume of business, marketing associations transact twenty times the business handled by purchasing agencies. Membership in the co-operative marketing associations which reported to the Economics Branch numbered 318,597 persons as compared with 30,546 members in purchasing organizations. The total annual business amounted to \$138,025,004 for the marketing companies compared with \$7,278,950 for the purchasing group.

In view of the steady growth of co-operative activity in Canada, consideration may be given to a number of features generally regarded as fundamental in a co-operative act. These are listed below without discussion.

1. Membership to be confined to or composed largely of producers or persons who expect to patronize the association.

2. The sale of capital stock should be confined to producers or persons who expect to contribute to the business of the association unless it is necessary to finance by public subscription in which case stock sold to persons other than users of the services of the association should be of non-voting type.

3. Voting power and control of the organization must be retained by those who use the services of the organization.

4. Some limitation on the amount of stock which a person may own.

5. A limitation of the rate of dividends on stock.

6. Provision for crediting patronage refunds to non-members and members as payments on new or additional stock.

7. Transfer of shares subject to the approval of directors.

8. Limitation of voting to "one-man, one-vote" or some other manner of voting which gives substantially this effect. (Voting on basis of business done during preceding fiscal years is worthy of consideration.)

9. Limitation of individual liability for debts of the association.

10. Provision for the use of a contract if desired by members.

11. Statement of method by which dissolution may be effected.

12. Provisions that after all expenses are provided for out of gross income, the balance for distribution may be apportioned among the following:—

- (a) An adequate reserve.

- (b) Interest on invested capital.

- (c) An educational fund (optional).
- (d) Balance distributed among eligible patrons of the association in proportion to volume of business contributed.
- 13. A limitation on the amount of business which may be done with non-members and non-producers.
- 14. Outline of duties and responsibilities of directors.
- 15. A restriction of the use of the term "co-operative" in names of associations.
- 16. Requirement that an annual return or statement of business, membership, etc., be filed with the registrar of such associations.
- 17. Provision for audit of books and accounts by a qualified person.

NEW ZEALAND DAIRY INDUSTRY COMMISSION REPORTS

The report of the New Zealand Dairy Industry Commission is of considerable interest to Canadian readers. This Commission was appointed by the Governor General under authority of the Dairy Industry Act of 1908 and the Dairy Export Control Act 1923, and was given the task of finding a solution to the crisis which has arisen in the industry by reason of the current high cost of production of butterfat and a reduction in price obtainable overseas for butter and cheese produced in New Zealand. The report submitted to the Governor General on September 30, 1934 reviews in detail the problems confronting the New Zealand dairy industry. Some of the significant facts are given below. Emphasis is placed upon the sensitiveness of the economic structure of New Zealand to external conditions. This arises from the fact that the greater part of the national income must be obtained from the sale of a few kinds of products in export markets.

"The economic problems which confront New Zealand at the present time and which are of particular moment to the dairy industry arise out of the changes in the nature of international trade that have occurred in post-war years. The most notable feature of these changes has been the rapid growth of policies of national self-sufficiency in practically all European countries. Particularly in recent years have restrictive trade practices increased both in scope and intensity, with the result that exporting industries have found it more and more difficult either to hold markets previously established or to penetrate new markets.

The extreme range of variability in cost of production between districts is somewhat over one pence per pound of butterfat with an average cost of 4.093 pence per pound for the 550 farms covered by an investigation conducted by the Department of Agriculture in the main dairy districts of the North Island. The farms selected for study were regarded as being above average in efficiency and were chosen because the owners were able to provide reasonably accurate records of receipts and expenditures. The Commission found that despite low costs of production (exclusive of interest) that the present output which was considered to be far short of the potential supply was at present incapable of being marketed at remunerative prices to the farmer.

"Looking at the situation from the farmers' point of view, we are at once impressed by his achievements in increasing production, and by the fact that his increased output has brought him no gain." Between 1920 and 1934, the average butterfat production per cow increased by approximately 68.7 pounds. Total imports of cheese to the United Kingdom market have been fairly uniform since 1925 approximating 150,000 tons. New Zealand's exports have increased but in view of the fact that total imports have not increased, it is considered probable that the saturation point may be approaching or that it actually has been reached. This is emphasized by the fact that there has been some decrease in the per capita consumption of cheese and until the situation is clarified, it is not considered to be wise to further develop export of cheese.

Increased consumption of butter in Great Britain has been obtained to some extent through a gross increase in fat consumption but mainly at the expense of margarine. Recently, the rate of displacement has been less rapid despite reductions in the price of butter.

Analysis of butter stocks shows that increasing difficulty is being experienced in moving butter rapidly in this market. The estimated stocks of butter in London, including stocks in private and provincial stores and in steamers not discharged as at 1st October were as follows:— 1932—20,000 tons, 1933—26,000 tons, and 1934—37,000 tons. There is no information as to the source of supply of this stored butter, but it is estimated that 40% of the 1934 quantity is of foreign origin, principally from the Baltic States and Russia; 40% is New Zealand butter and the remaining Australian and Irish."

The commission anticipates that the Government of the United Kingdom will impose a limit on imports of dairy produce with or without the levying of differential duties, and will, in fixing quotas within that limit, have regard to the relative claims of Empire and foreign countries. Should quantitative restrictions be placed on the export of dairy products, possibilities of controlling the rate of production may have to be considered. The report states that any subsidy which is virtually a sustenance payment would be viewed with disfavour by the United Kingdom. The risk involved in abandoning at this date our policy of unsubsidized export is too serious to be undertaken on behalf of a proposal which has no outstanding merits of its own."

"It is recommended that control of the industry be entrusted to a new Dairy Produce Control Board. This Board should in addition to its other activities control the local marketing of butter and cheese. Envisaging the necessities of the industry in regard to new markets for surplus produce, and the measures of control of production and marketing likely to become necessary to meet the present and future problems of the industry, as well as control of the local marketing of butter and cheese, to which reference has been made elsewhere in the report, the Commission believes that the State must of necessity appoint some members of the Board. The proposal that farm and factory instruction should be the responsibility of the newly constituted Dairy-produce Control Board is an additional reason for the State interest in the appointment of the Board. For these reasons, the Commission has decided to recommend for the Board a constitution which it is considered gives recognition and fair balance to the interests both of the State and the producers.

It is, therefore, recommended that the Dairy-produce Control Board be reconstituted and given wider powers, embracing control of volume and quality of the production, processing, and manufacture of dairy-produce and control of local marketing as well as export marketing."

The Bureau of Agricultural Economics, Washington, D.C., recently released a report on direct marketing of hogs. A press release announcing the report states: "Direct marketing has not lowered the general level of hog prices, nor has it operated to reduce returns to producers. The sharp decline in hog prices in recent years was due to the drastic reduction in consumer income associated with the decline in the general price level, and to reduced foreign demand for American hog products. It has not reduced competition for hogs. There are no fixed price differences between public markets and interior points. A rise or decline in hog prices is as likely to occur first at interior points as at public markets. Direct marketing has not increased marketing costs nor widened the margins between prices of hogs and prices of hog products. Nor has it deprived public markets of supplies of the various qualities of hogs sufficient for registering prices for the different grades. In general, the study shows that direct marketing has not operated to the disadvantage of hog producers. It does point out, however, that direct marketing has substantially reduced the number of hogs received for sale at public markets, which has adversely affected the interests of stockyard operators and market agencies at some public markets."

FARM LABOUR

E. G. GREST¹

The family size of farm is often referred to as the best size of farm with which to build up a permanent agriculture in Western Canada. This particular size of farm is difficult to translate into a definite number of acres of land in any area as the size of family varies considerably from farm to farm and even varies a great deal in size through one generation. The majority of farms in Western Canada approach very closely to a family business; for example, during the year 1930 in five main areas in Alberta and Saskatchewan 82.7% of all the farm labour used on 573 farms was supplied by the farm operator and his family.²

Amount and Cost of Labour.—The amount of the different types of hired and family labour used on these farms and the cash value including cash expenditure for board are shown in Table 1. The average cost of board was \$7.46 per month. This was included in the total cash value or cost of labour and the cash value of labour per month shown in Table 1. The non-cash cost of living is the amount of farm garden produce, farm supplied meats, milk, eggs, and dwelling accommodation used by the whole labour force. The average cost of man labour for these farms in 1930 was 35.2 cents per hour or \$57 per month.

TABLE 1.—COST OF HIRED AND FAMILY LABOUR USED ON 537 FARMS IN SASKATCHEWAN AND ALBERTA DURING THE YEAR ENDING APRIL 1, 1931

| | Months of labour | | Cash cost of labour | | Cash cost per month |
|------------------------------------|------------------|----------|---------------------|----------|---------------------|
| | Total | Per farm | Total | Per farm | |
| Hired labour: | | | | | |
| Year help | 490.0 | 0.91 | \$20,080 | \$37 | \$41 |
| Month help | 935.8 | 1.75 | 46,389 | 86 | 50 |
| Day help | 565.5 | 1.05 | 50,313 | 94 | 89 |
| Total hired labour | 1,991.3 | 3.71 | \$116,782 | \$217 | \$59 |
| Family labour: | | | | | |
| Farm operator | 6,184.8 | 11.52 | \$324,542 | \$605 | \$52 |
| Wife of operator | 302.3 | 0.56 | 9,631 | 18 | 32 |
| Operator's sons | 2,680.9 | 4.99 | 99,072 | 184 | 37 |
| Other unpaid labour | 362.7 | 0.68 | 14,749 | 27 | 41 |
| Total family labour | 9,530.7 | 17.75 | \$447,994 | \$834 | \$47 |
| Total hired and family labour | 11,522.0 | 21.46 | \$564,776 | \$1,051 | \$49 |
| Total non-cash living | — | — | 90,017 | 168 | 8 |
| Total value of labour | — | — | \$654,793 | \$1,219 | \$57 |
| Total hours man labour | — | — | 1,816,419 | 3,466 | — |
| Cost per hour in cents | — | — | 35.2 | — | — |
| Family labour in per cent of total | 82.7 | — | 79.3 | — | — |

Since the family supplied slightly over four-fifths of all the farm labour on these farms in 1930 the problem was to find sufficient useful employment for this labour throughout the year. Family labour did not vary greatly with the seasons of the year and in most cases was available for the full 12 months. The farmer usually

¹ Formerly Field Assistant, Agricultural Economics Branch, Department of Agriculture, Ottawa.

² Study conducted in co-operation with the Canadian Pioneer Problems Committee, 1931.

does not pay out a definite cash wage for family labour, but food, clothing and incidentals must be provided and consideration must also be given to the fact that the farmer's son working on his father's farm is investing his time in the farm business and is entitled to a portion of the farm or to financial assistance when starting in business for himself. In view of this fact a charge for family labour is considered a legitimate cost. Moreover, in order to place all farms on a comparable basis, family labour must be charged against the business. A good farm operator will not be more wasteful of family labour than he would be of seasonal hired help but it is very frequently the case that family labour is available in excess of farm needs. Such a situation might be overcome by increasing the size of the farm or by modifying the type of business so as to provide employment for the additional help throughout the year.

Factors Affecting the Cost per Hour of Man Labour.—The importance of obtaining a maximum number of hours of work per man per year is demonstrated in Table 2. There is a very definite decrease in the cost per hour of man labour with an increase of hours worked per year. This is shown by a rate of 47.6 cents per hour for the group working less than 1,500 hours per man per year and a labour cost of 26.3 cents per hour for those working 2,500 hours and over per year.

TABLE 2.—INFLUENCE OF HOURS WORKED PER MAN EQUIVALENT AND TIME SPENT CARING FOR LIVE STOCK ON THE COST OF LABOUR PER HOUR ON 537 FARMS IN SASKATCHEWAN AND ALBERTA 1930-31

| Per cent of hours spent caring for live stock | Hours worked per man equivalent | | | | | | | | | |
|---|---------------------------------|----------------------|-----------------|----------------------|-----------------|----------------------|-----------------|----------------------|-----------------|----------------------|
| | Under 1,500 | | 1,500-1,999 | | 2,000-2,499 | | 2,500 and over | | All farms | |
| | Number of farms | Labour rate per hour | Number of farms | Labour rate per hour | Number of farms | Labour rate per hour | Number of farms | Labour rate per hour | Number of farms | Labour rate per hour |
| | | (cts.) | | (cts.) | | (cts.) | | (cts.) | | (cts.) |
| Under 30% | 40 | 58.3 | 28 | 41.7 | 19 | 38.1 | 6 | 26.0 | 93 | 43.4 |
| 30-39% | 20 | 44.6 | 42 | 39.0 | 38 | 36.8 | 26 | 30.0 | 126 | 36.8 |
| 40-49% | 34 | 45.3 | 44 | 37.5 | 52 | 29.8 | 37 | 25.7 | 167 | 33.1 |
| 50% and over | 26 | 39.9 | 44 | 35.9 | 39 | 28.0 | 42 | 24.3 | 151 | 30.6 |
| All farms | 120 | 47.6 | 158 | 38.3 | 148 | 32.6 | 111 | 26.3 | 537 | 35.2 |

The data were also sorted according to the percentage of labour spent on caring for live stock as well as according to the percentage of field work accomplished by horses. As the percentage of the total hours spent on choring increased, the cost of man labour per hour decreased and hours worked per man increased. The decrease in labour cost per hour is not entirely due to the increase in hours worked per man but probably one-half could be attributed to this factor. The inclusion of a certain amount of live stock in the farm business assists in making use of family labour throughout the year, and hired labour can be obtained for short periods such as during harvesting when more labour is required than can normally be supplied by the operator and his family.

On farms on which only a portion of the field work is done with horses and the balance with tractors it would be expected that the percentage of time spent in caring for all live stock, including horses, would be less than on farms on which all of the field work is done with horses. This fact is brought out in Table 3. The decrease in time spent caring for live stock must be almost entirely due to the fact that less time was spent in caring for horses, as the returns from live stock and live stock products sold and consumed on the farm per man equivalent is practically the same in each group with the exception of the group of farms in which 99 to 67% of the field work was done by horses. The decrease in hours worked per man with the increased use of the tractor for field work is almost negligible. The use of the tractor is therefore responsible for only a small share of the increase in the rate for man labour.

TABLE 3.—INFLUENCE OF HOURS WORKED PER MAN EQUIVALENT AND PERCENTAGE OF FIELD WORK HANDLED BY HORSES ON THE COST OF LABOUR PER HOUR ON 537 FARMS IN SASKATCHEWAN AND ALBERTA 1930-31

| Per cent of field work handled by horses | Hours worked per man equivalent | | | | | | | | | |
|--|---------------------------------|----------------------|-----------------|----------------------|-----------------|----------------------|-----------------|----------------------|-----------------|----------------------|
| | Under 1,500 | | 1,500-1,999 | | 2,000-2,499 | | 2,500 and over | | All farms | |
| | Number of farms | Labour rate per hour | Number of farms | Labour rate per hour | Number of farms | Labour rate per hour | Number of farms | Labour rate per hour | Number of farms | Labour rate per hour |
| | | (cts.) | | (cts.) | | (cts.) | | (cts.) | | (cts.) |
| 100% | 68 | 42.9 | 82 | 35.7 | 77 | 29.2 | 69 | 24.2 | 296 | 32.0 |
| 99-67% | 9 | 48.6 | 23 | 39.5 | 20 | 33.0 | 13 | 27.3 | 65 | 35.6 |
| 66-34% | 15 | 47.0 | 27 | 39.2 | 29 | 34.5 | 15 | 27.7 | 86 | 36.3 |
| 33-0% | 28 | 62.7 | 26 | 43.9 | 22 | 37.6 | 14 | 33.2 | 90 | 43.3 |
| All farms | 120 | 47.6 | 158 | 38.3 | 148 | 32.6 | 111 | 26.3 | 537 | 35.2 |

The inclusion of live stock on the tractor-operated farms should give nearly as good a distribution of labour requirements throughout the year as on the horse-operated farms because the live stock kept would require considerable attention during the winter while horses on farms as a rule are running out during the winter and receive little attention. Therefore, the increased cost of labour per hour must be due to the better trained class of labour required on the tractor-operated farms. On account of the higher class of labour used, it naturally follows that a representative sample of farm operators would estimate labour at a higher monthly rate which results in increasing the cost per hour.

TABLE 4.—RELATIONSHIP OF ACRES OF CROPLAND TO PERCENTAGE OF HOURS SPENT CHORING AND HOURS PER MAN EQUIVALENT —537 FARMS IN SASKATCHEWAN AND ALBERTA 1930-31

| Per cent of hours spent caring for live stock | Hours per man equivalent | Live stock returns per man equivalent | Per cent hours spent choring | Size of farm (Acres of cropland) |
|---|--------------------------|---------------------------------------|------------------------------|----------------------------------|
| Under 30% | 1,725 | \$160 | 23.3 | 622 |
| 30-39% | 1,949 | 284 | 35.2 | 570 |
| 40-49% | 1,956 | 335 | 44.3 | 446 |
| 50% and over | 2,071 | 451 | 56.6 | 306 |
| All farms | 1,939 | 317 | 41.6 | 466 |

From data on labour costs not presented in the tables it was found that the cost of man labour per hour increased more or less regularly as the farms increased in size. This was probably due to a better trained class of labour being required on the larger farms. On the larger farms the family labour and the operator's labour in particular was usually estimated at higher rates per month than on smaller farms. The average size of farm is shown in the final columns of Table 4. The variation in labour rates in the first section of Table 2 which cannot be accounted for by the difference in hours worked per man, was probably due to the factors just mentioned which cause the labour rate to rise with increases in the size of farm. The inclusion of farms in the sample with comparatively large acreage was partly responsible for the higher cost of labour per hour on farms on which all the work was done by horses compared with those which had 99 to 67% of the field work done by horses. The smaller farms show higher percentages of man labour spent on choring.

THE AGRICULTURAL OUTLOOK PROGRAMME

Considerable interest was aroused throughout Canada during 1934 by the appearance of a publication entitled *The Agricultural Situation*. That interest has been further stimulated by the release early this year of the second of such reviews under the revised title, *The Agricultural Situation and Outlook, 1935*. Since enquiries have been made concerning this undertaking, it was thought that some information on the subject might be of value to readers of the *Economic Annalist*, particularly those outside Canada. Many will be familiar with the programme in the United States; to them the method of conducting the undertaking in Canada may be of interest.

Object.—First, with regard of the object of such an undertaking, it should be noted that, while we have for years had well organized intelligence and statistical services, and in some instances periodic reviews of the agricultural situation, we have not had an annual appraisal of the industry as a whole; we have had nothing that corresponds to the inventory that any well-run business is accustomed to. The object, then, of such a programme is to fill a gap in our service and in doing so, to supplement and co-ordinate, rather than displace, existing activities.

The recipients of such a service are, of course, the farmers and others interested in agriculture. For the farmer it is hoped the Outlook report will provide information at a time when it can be used in making plans for crop and live stock production for the ensuing year or period of years. To others its principal value will be found in the provision of a comprehensive review of the status of an industry in which most of us have an interest, direct or indirect.

Advisory Council Sponsors.—The work in this country is sponsored by the National Advisory Council on Agricultural Services. This body represents all Departments, Universities, Colleges, and Research bodies interested in the development of Agriculture. The council in 1932, and again in 1933, at general meetings heard recommendations from subcommittees that an agricultural outlook program be initiated. In response to such requests the executive of the Council in the fall of 1933 appointed a committee, two of whom represent the Departments of Agriculture and Trade and Commerce in the Dominion Government and the third the provincial agricultural institutions, to arrange for such a service.

The constitution of this "Agricultural Outlook Committee" is significant, for it recognizes the need for a co-operative approach to the conduct of this particular undertaking. The resulting programme is not the product of a single department or institution. The principle thus recognized was further emphasized by the Committee on the appointment of subcommittees. The latter in turn are made up of officials of the several departments at Ottawa that are in a position to contribute information or assistance. Moreover, the subcommittees are composed of men representing, as far as possible, the different divisions of agricultural activity. Thus on the 16 committees that prepared the 1935 report the Departments of Agriculture, Trade and Commerce, External Affairs, and Finance are represented, and in addition each committee has been selected so as to ensure that all phases of the production and marketing problem are adequately presented; the Experimental Farms Branch, the National Research Council, the Markets Divisions of the Department of Agriculture, together with the Commercial Intelligence Service, The Dominion Bureau of Statistics, the Entomological Branch, and the Economics Branch are represented. In addition, where an appreciation of the problem confronting agriculture depends upon a knowledge of the internal financial situation or upon information concerning developments in other countries, the appropriate departments are represented. Editorial and publicity committees insure satisfactory presentation and distribution of data.

Scope and Procedure.—The Outlook Committee in consultation with subcommittees decided that the report should summarize the general agricultural situation and outlook—domestic, empire and foreign—and then deal with specific agricultural

commodities. Subcommittees have been selected to give effect to this policy. The trend of business activity, employment, and international trade is considered in dealing with commodities and is featured in the general introductory sections.

The procedure followed has been to request the special committees to prepare reports on the subjects or commodities assigned them. The members of each committee, who by virtue of their positions in the respective services are in possession of, or have access to, the best available information on the matter they are to deal with, bring such information to the committee. Where additional data are required the departments are requested to provide them. Reports, insofar as possible are uniform in type of content—each is intended to summarize production, distribution, storage holdings, prices, competition, and demand. Committees meet with one another when the matters dealt with are inter-related.

About a month has been allowed for the preparation of reports following which a general conference has been called. To this conference the provinces have been invited to send representatives. This year the reports were sent, in preliminary form, to provincial Departments of Agriculture for consideration prior to the Outlook Conference.

At this general conference each committee report is presented and analyzed. There is thus brought to bear upon the final report, not only the best efforts of those immediately concerned with the subject or commodity under consideration but also the opinions of those concerned with other phases of agriculture. The completed report thus represents the considered opinion of persons whose work brings them into intimate contact with all phases of the matter under review.

Passing reference should be made to the value of this final conference to those engaged in agricultural work. Offering as it does a chance to hear the whole situation reviewed it has given to the specialized worker an opportunity that has heretofore been lacking. If and when provincial representation at this gathering is more general, it should provide an opportunity for dealing with many matters related to agricultural development.

Printing and Publicity.—The final report has been printed in both English and French and widely distributed. In addition the press has been provided with summarized statements dealing with each phase of the report and these have been widely used. The co-operation of the Publications Branch of the Departments of Agriculture and the Publicity Division of the Department of Trade and Commerce has been most helpful in this connection. A National broadcast has been arranged each year with the assistance of the Canadian Radio Commission in which the "highlights" of the report were reviewed by the Deputy Minister of Agriculture, Dr. H. Barton.

Extension Programme.—In the United States, where an Outlook report has been prepared for some years, the national undertaking has been supplemented by state reports and by a well organized programme of extension work. In Canada only two provinces, Nova Scotia and Saskatchewan, have so far undertaken such work and in these instances the work antedated the federal programme. In Nova Scotia the agricultural representative service has used both provincial and federal Outlook reports extensively, but in other provinces there appears to have been little concerted effort to popularize such information. The National Outlook Committee appreciates that it has some responsibility in this connection. An effort has been made this year to meet the situation in a measure. Supplementary data were prepared for the use of extension workers and an effort was made in a small way to demonstrate the value of Outlook information at farmers' meetings. This phase of the service should be developed, but maximum results are not to be expected until provincial reports are prepared and the whole programme, federal and provincial, is co-ordinated.

Summary.—The response to this programme has been very gratifying. The Agricultural Journals and other press have made extensive use of the material furnished and the demand from farmers and business leaders for copies of the report has been very satisfactory. Its place in Canadian Agriculture will likely be one of increasing importance.

ECONOMIC LITERATURE

MORTENSEN, W. P. Economic Considerations in Marketing Fluid Milk. Research Bulletin 125, Agricultural Experiment Station, University Wisconsin, Madison, Wisconsin.

This 56-page bulletin is divided into five sections: Market Price Plans and Policies, Distributors' Margins, Analysis of Distributor Costs and Profits, Public Control of Milk Distribution, and Competition of Evaporated Milk with Fresh Milk.

Under normal competitive conditions, the prices of the various types of milk products tend to move up and down in unison. Fluid milk prices while moving in sympathy are on a higher plain due in part to protection of various kinds which the producers of fluid milk have provided for themselves. During the depression period, the comparatively attractive fluid milk price induced fluid milk producers to increase their output and producers outside the fluid milk zone to break down the barriers which have kept them out of this field. The two factors together have produced a condition of heavy surplus on the fluid milk market with resultant chaos.

Analysis of Returns and Costs.—In comparing the conditions prior to the depression 1927-1929 with the depression years 1931-33, it is revealed that in six Wisconsin cities that "the distributors' margin was reduced only 0.2 cents per quart between these two periods, while the farmer's price was reduced 1.7 cents. The total reduction in the retail price during the period was 1.9 cents per quart. This pronounced decrease in price paid farmers compared with the reduction of distributors' margin, is apparently typical during periods of rapidly falling prices." Concerning distributors' profits, the writer states, "It is noteworthy that if profits of these companies had been cut in half for the six-year period (which would have left about the equivalent of a normal interest rate on money invested) it would have meant a saving of about one-fifth cent per quart sold at retail. While the importance of this is not to be neglected, it is evident that if any very substantial reduction in distributors' margins is to be achieved, other and larger savings must also be effected. These must come as the result of the elimination of inefficiencies and of unnecessary costs." An analysis of distribution of returns to farmers shipping to condenseries is summed up: "From this, it appears that farmers suffered doubly: First, by low prices paid by consumers; Second, by the fact that the farmers did not continue to obtain the same proportion of the consumer's dollar as they received before the fall in prices."

The relative prices of whole milk and evaporated milk have so moved during the past few years as to increase the per capita consumption of evaporated milk. This is a distinct blow to the fluid milk business as the evaporated product readily replaces the bottled milk when price differentials warrant.

Relatively high prices for fluid milk encourage substitution, reduce consumption, attract increased product to that market, induce competition from fields regularly outside the fluid milk production zones, and as the author states, "If producers of city milk lose sight of the fact that they are inseparably a part of the whole dairy industry they are bound to invite difficulty. A price structure built on quicksand is too insecure to serve dairymen properly who are in business on the basis of a long period."

Excessive operating costs in milk distribution can largely be traced to (1) under-capacity operation and (2) duplication of effort and equipment. To meet this situation, producers and consumers must choose between that system of milk distribution which operates with unnecessarily large concerns providing abundant service and that of a limited number of organizations under some kind of public control.

Public control may be of three types: (1) Public control with private ownership (under the A.A.A., this method is in operation with some degree of success in several states); (2) Public control with limited private ownership; and (3) Public ownership. Numbers 2 and 3 are considered to be suggestions for a permanent rather than a temporary control programme. It is believed that a programme such as will give farmers an opportunity to bargain with distributors directly or through strongly organized agencies would give as high a farmers' price as local and general conditions warrant.

NOTES

The First Annual Report of the Pigs Marketing Board for Northern Ireland has been issued recently. It is interesting to note the early decision of the Board "to start investigations and the collection of information on which to build up their policy; that any drastic immediate action was undesirable, and that for the moment no change in marketing methods should be made, but that dead pig prices should be fixed in negotiation with the Bacon Marketing Board (who represented the curers). This decision was taken with a view to ridding the industry of the curse of pig price variations from week to week and to enable producers to take advantage of the higher pork price which curers could afford to pay as a result of the reduction of bacon imports."

Mr. A. Leitch, formerly Professor of Agricultural Economics, Ontario Agricultural College, Guelph, and more recently associated with the development of the tobacco industry in Norfolk County, Ontario, has been appointed Chairman of the Dominion Marketing Board. He will, however, retain some connections with the tobacco business. Dr. H. Barton, who was formerly chairman of the Board, has asked to be released from the duties of this position as the duties of the Deputy Minister of Agriculture are onerous and the responsibilities which are attached to the chairmanship of the Board are rapidly increasing.

The annual index of prices of agricultural produce in Great Britain (1911-13 = 100) was 114 in 1934 compared with 107 in 1933. If allowances are made for emergency payments under the Wheat Act of 1932 and the Cattle Industry Act of 1934, the index would be 119. The chief factors responsible for the rise in the index were higher prices for fat sheep, fat pigs, milk, wool, hay, potatoes, barley, and oats. Lower prices were recorded for fat cattle, wheat, dairy produce and fruit.

Mr. H. R. Hare, formerly in the Department of Animal Husbandry, University of British Columbia, has joined the staff of the Economics Branch of the Department of Agriculture, Ottawa. While on the staff of the University of British Columbia, Mr. Hare conducted a Dairy Farm Management study based upon 180 farms. Data were obtained over an eleven year period, 1921-31.

The monthly letter of the Canadian Bank of Commerce for December emphasizes the importance of farm purchasing power. A new index of Canadian farm purchasing power has been constructed which records the fluctuations quarter by quarter during the past eight years. In 1934 the index was 64.64 at the end of the first quarter, 65.27 at the end of the second quarter, and 67.51 at the close of the third quarter.

Creamery butter in storage in Canada February 1, 1935, amounted to 22,344,540 pounds as compared with 31,543,203 pounds as of January 1, and a five-year average of 16,072,031 pounds. While the stocks showed a decrease of 29.7% during January, holdings on February 1 were 52.7% above those on hand at the same date in 1934.

Total expenditures of the United States Agricultural Adjustment Administration from May 12, 1933, to December 31, 1934, were reported to be \$773,983,535 of which \$527,501,795 represent rental and benefit payments and \$170,296,958 for surplus removal operations. The balance represented the cost of administration. Processing taxes have returned \$640,871,403.

Mr. S. C. Hudson, Economics Branch, Department of Agriculture, Ottawa, has been granted leave of absence for the purpose of continuing work in the Graduate School at Cornell University.